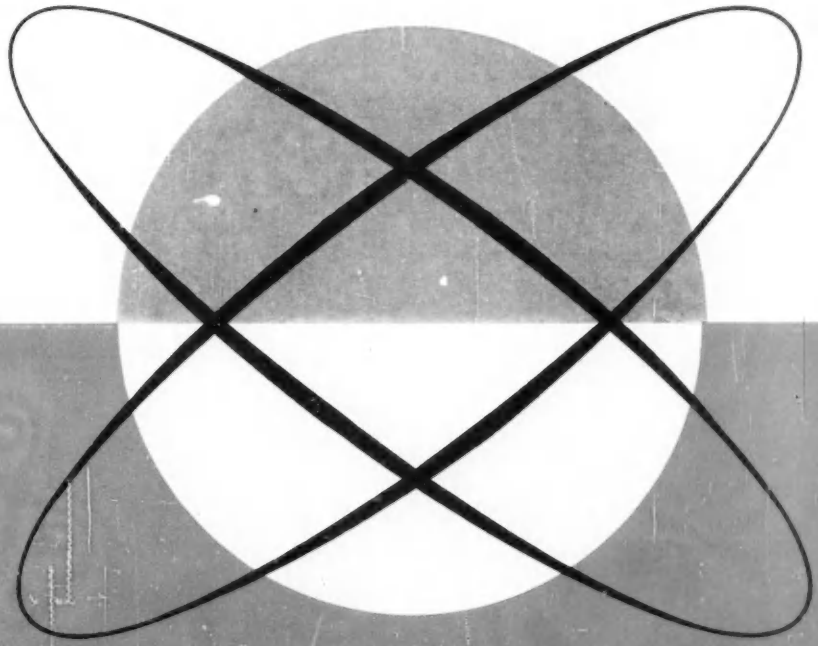
Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

A McGraw-Hill Publication

75 Cents

JANUARY 1961

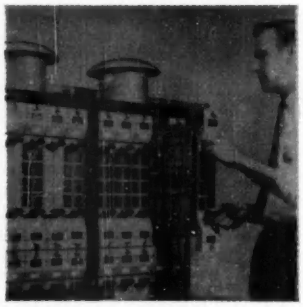


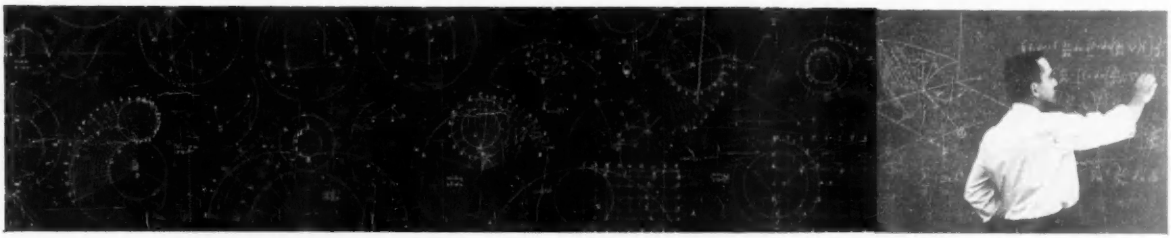
INFORMATION SYSTEMS IN CONTROL ENGINEERING

Starting with this issue a special feature department will concentrate on the coverage of information systems in control engineering. This department will permit increased emphasis on automatic data gathering, data transmission, data processing, and information display.

LIBRASCOPE COMPUTER FACILITIES

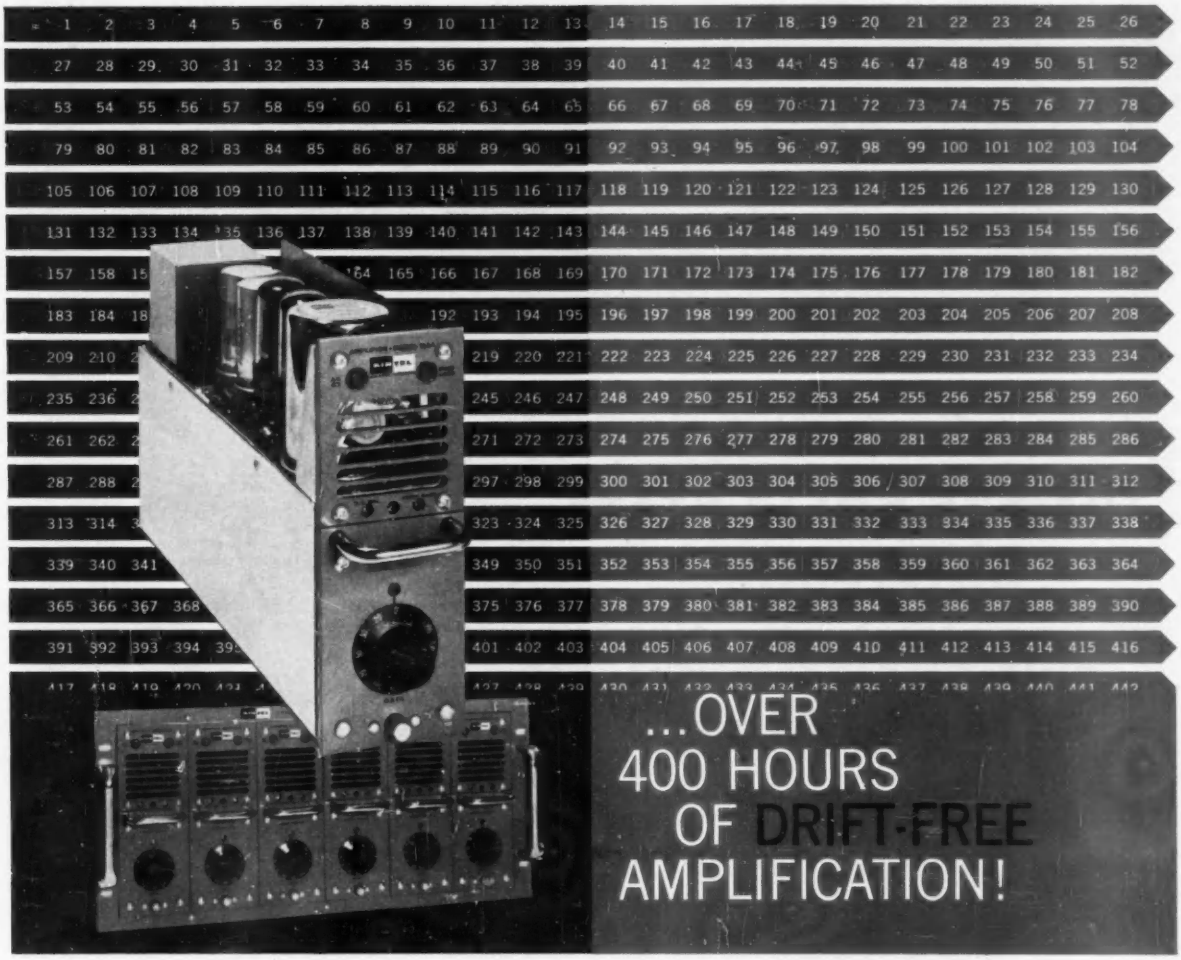
Shown below is a composite view of Librascope's facilities where a variety of computer systems are currently in different stages of design and production. Some are strategically involved with national defense...others deal with business and industrial process control. Each is uniquely designed to answer a particular need. The success of these systems illustrates the value of Librascope's engineering philosophy: A decentralized organization of specialized project teams responsible for assignments from concept to delivery...and backed up by excellent research, service, and production facilities. For your computer requirements, call on the company whose breadth of diversification in computer technology is unsurpassed. ■ Librascope Division, General Precision, Inc., 808 Western Avenue, Glendale, Calif. For career opportunities write to John Schmidt, Engineering Employment. ■





computers that pace man's expanding mind

CIRCLE 189 ON READER SERVICE CARD



Less than 2μv of drift for over 400 hours of continuous operation! That's just one of the many outstanding features of KIN TEL's new 112A wideband DC amplifier—the unit that is the successor to KIN TEL's 111 series DC amplifiers. Frequency response is from DC to beyond 40 kc, output capability up to 45 volts. It has an integral power supply, fits the same cabinets and modules, and can be used to replace any KIN TEL Model 111 amplifier.

HIGH ACCURACY. The 112A amplifies microvolt-level signals from DC to 2 kc with a gain accuracy of $\pm 0.5\%$ on any gain setting, better than $\pm 0.01\%$ accuracy on individual gain settings by means of the Micro-Gain adjustment.

RELIABILITY. Overall dissipation has been reduced and reliability enhanced by replacing the tubes used in the 111 amplifier power supply with silicon rectifiers in the 112A. Special heat-conducting shields, heat sinks, and an improved mechanical layout further improve cooling efficiency. Polystyrene capacitors are used in all critical areas. Rugged, militarized components are used wherever compatible with required performance characteristics. Write today for technical information or demonstration.

PRICES:

112A Amplifier with a 112A-A plug-in unit that permits 10 gain steps from 20 to 1000 with 1 to 2 times vernier adjustment at each step... $625

112A Amplifier with a 112A-B plug-in unit that converts the amplifier to a +1 unit having an input impedance over 10,000 megohms, a gain accuracy within $\pm 0.001\%$... $615

195 Single amplifier cabinet... $125

191A Single amplifer 19" rack module... $150

190 Six amplifier 19" rack module... $295

Immediate delivery from stock in reasonable quantities.
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5725 Kearny Villa Road, San Diego 11, California, Phone: BRowning 7-6700

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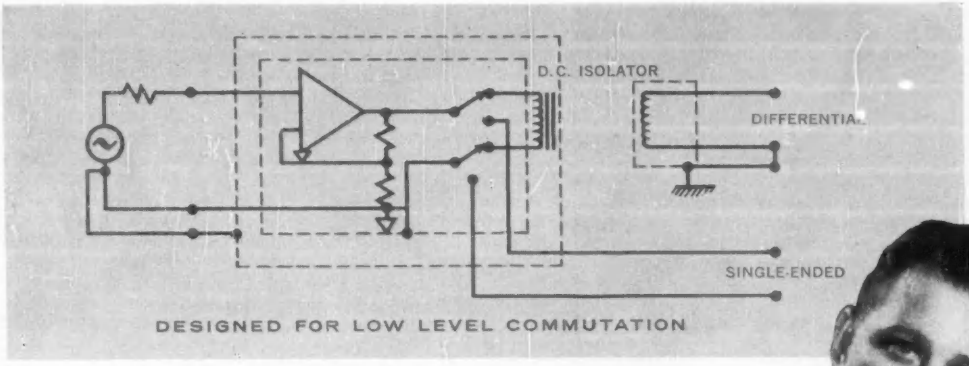

Announcing the

TDA 875 SOLID STATE

Differential and Single-Ended AMPLIFIER*

- *Recovery from 500% overload in 300 microseconds.*
- *Output voltage clamped at ±13 volts, can't burn out delicate recording equipment.*
- *Completely isolated, 3000 megohm leakage path to ground.*

Built to meet the needs of the engineer designing low-level multiplexing systems, Epsco-West's new TDA 875 Differential Amplifier features high reliability, high gain, wide band-width, negligible drift, high ac/dc common mode rejection, low noise, fast rise time, fast recovery time, integral power supply, and high input impedance. No other amplifier combines all these design parameters to such a useful degree.

DESCRIPTION

The Model TDA 875 contains an integral power supply which operates from a 117-volt, 60-400 cps line, requiring only 15 watts of power. Chopper drive circuits are included with each amplifier.

Two modes of operation are available: differential and single-ended (potentiometric); selection is made by means of a front panel control. Five fixed gains are also chosen by a front panel switch.

In its differential mode, the amplifier provides ±10 volts at 10 milliamperes as its full scale output; in its single-ended mode, full scale output is ±10 volts at 50 milliamperes. High input impedance ensures that all transducer voltage will appear at the amplifier input terminals. Changes in transducer or line resistance will have little consequence.

The Model TDA 875 Amplifier may be mounted in the Model TDA 870A Carrying Case for easy portability, or in the Model TDA 870 Rack Adapter which holds 5 amplifiers in a standard 19-inch relay rack.

**One of six new E-W amplifiers now available to meet your low-level instrumentation needs.*

Ask your nearby Epsco-West engineering representative to demonstrate these new amplifiers. For complete technical information, write for Brochure No. 875. ***Please address Dept. 21.***

CRITICAL SPECIFICATIONS
(Differential Mode)

VOLTAGE GAIN
Fixed steps of 1000, 500, 200, 100, 50. Lower gains optional.

LINEARITY
±0.05% of full scale (20 volts at dc)

INPUT IMPEDANCE
Greater than 100 megohms shunted by 0.002 microfarad.

COMMON MODE LEVEL
±300 volts dc, 117 volts rms ac

TRANSIENT COMMON MODE RECOVERY
300 volt step of common mode voltage does not cause overload.

DRIFT — 40 HOURS
±2 microvolts referred to the input, plus ±0.02% of full scale at 25°C.

DRIFT — 6 MONTHS
±4 microvolts referred to the input, plus ±0.02% of full scale at 25°C.

NOISE REFERRED TO THE INPUT
Less than 2 microvolts peak-to-peak (99% confidence) from dc to 20 cps. Less than 5 microvolts rms from dc to 5 kc for source resistances of 1000 ohms or less.

SETTING TIME
300 microseconds to within 1% of final value all ranges.

OVERLOAD RECOVERY TIME
300 microseconds or less to within 1% of final value from 500% overload.

SHORT CIRCUIT PROTECTION
Sustained output short circuit will not damage amplifier.

Epsco-West
A Division of Epsco, Inc.
240 E. PALAIS RD., ANAHEIM, CALIF. • PROSPECT 2-1000

8

Control ENGINEERING

JANUARY 1961

VOL. 8 NO. 1

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

65 **Hot Gas Control Systems—I: Basic Design Techniques**
A. E. SCHMIDLIN of Walter Kidde starts a three-part series explaining what hot gas reactive and servoactuator systems are, where to use them, and how to select hardware.

71 **New Continuous Path System Uses DDA Interpolator**
H. B. HENEGAR of the Bendix Corp. uses a digital differential analyzer to perform direct linear and circular interpolation in the Dynapath machine tool control system.

77 **Multiple Columns in Chromatography**
W. J. BAKER and *T. L. ZINN* of Monsanto explain the significant ways and benefits of using additional storing and backflushing columns to improve in-plant analyses.

83 **Data File 44—Guide to Semiconductor Voltage Regulators**
L. BLOOM of General Instrument Corp. offers a simplified procedure and chart to select the most appropriate solid state voltage regulator to fit the regulated circuit.

85 **Incremental Servos—III: 16 Applications for Stepper Motors**
S. J. BAILEY of Vitro Corp. of America follows up his two previous articles on incremental servos with selected usages ranging from converters to error-signal memories.

90 **Discontinuous Control Stops Train Accurately**
T. ITO of the Japanese National Railways follows through the development of automatic braking apparatus for rapid transit trains that positions the train within 4 in.

95 **Predicting Performance of Metering Pumps**
A. BEERBOWER of Esso Research derives a figure of merit for metering pumps and uses it to select a pump and anticipate its performance when scaling up a process plant.

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INFORMATION SYSTEMS

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111 **Automatic Plotting of Digital Computer Results**
M. BAIN of Jet Propulsion Lab. and *R. N. FLANDERS* of F. L. Moseley join forces in describing unique plotting system that turns computer digits into continuous curves.

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The new Leitz Leicana movie camera positions aperture with photoresistor and coil.

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With characteristics similar to tunnel diode, device may open way to new components.

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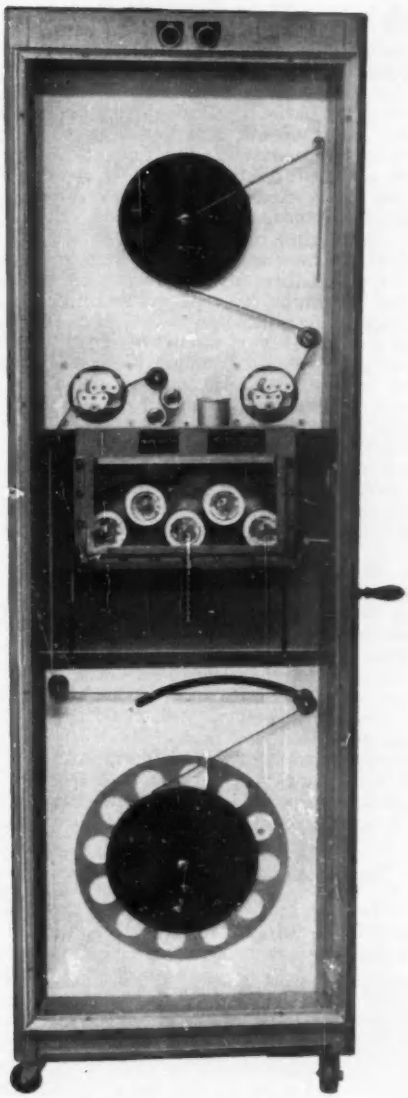
Clean your magnetic tape

- *Rapidly*
- *Safely*
- *Automatically*

with CMC's NEW SOLVENT CLEANER



Information stored on tape is not disturbed in any way. No drop-out, no distortion, no tape stretch. Head wear and damage is reduced by eliminating abrasive particles from tape surfaces.

All you have to do is put the tape in place and fill the solvent tank. The new CMC Model A-7070 cleaner does the rest automatically and speedily—with all scrubbing action taking place below the solvent level. It effectively cleans magnetic tape up to 2" in width at rates to 300 feet per minute with complete safety. Cleaning is accomplished by counter-rotating velvet covered scrubbing rollers, effectively removing ferrous oxide particles, dirt, lint, oil, fingerprints and wax.

COMPLETELY SELF-CONTAINED. *No vacuum pump or outside sources of air are required.*

FLUID CUSHION PROTECTS TAPE. *The fluid solvent forms a barrier between the scrubbing roller and tape to prevent scratches and abrasions. Only velvet fibres lightly touch the film.*

SPEED CONTROL. *Operate at any speed from 0 to 300 feet per minute with adjustable speed control. Automatic shut-off leaves unit threaded for continuous operation.*

COMPLETELY SAFE. *Uses only non-inflammable, non-explosive solvents. Fumes controlled. Automatic shut-off in case of defective splices.*

AUTOMATIC REWIND. *Makes necessary torque adjustment as reel size increases.*

LOW COST OPERATION. *Solvents are continuously filtered and reclaimed; waste held to minimum. One pint of solvent cleans 3,000 feet of 1" tape.*

PRICE. *Model A-7070 $5,500 f.o.b. Sylmar, California.*

If you have a tape cleaning problem, contact us and arrange to have a sample tape cleaned for your inspection. Contact your local CMC representative for complete technical details, or write for 4-page brochure.

(Please address Dept. 21.)

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Phone: EMpire 7-2161

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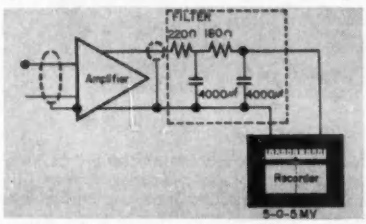
ZERO DRIFT

Accuracy in d-c amplifiers is fundamentally dependent on zero drift. This error, defined as any zero offset appearing at the amplifier output but not present in the input, is indistinguishable from the d-c input signal, and varies more or less sporadically with time and/or ambient temperature. Elimination of zero drift is a prime d-c amplifier design objective.

Evaluation of the amplifier zero drift characteristic is quite simple, but elimination of the effect is not. For example, any direct-coupled stage of amplification will drift due to the inability of circuit operating levels to remain constant. The use of inverse feedback does not have any beneficial effect on drift. The best generally accepted method of drift elimination is to make all amplification drift-free through a-c coupling, and converting the incoming d-c to a-c directly by means of a low-level modulator, such as a chopper or magnetic converter. After amplification, the a-c is demodulated into d-c which may be further amplified at high levels without appreciable zero error. This system is used in both the so-called chopper amplifier (where the band pass is limited by the chopper frequency) and the chopper-stabilized amplifier (where the chopper amplifier is combined with a wide band amplifier to give frequency responses well beyond the chopper excitation frequency).

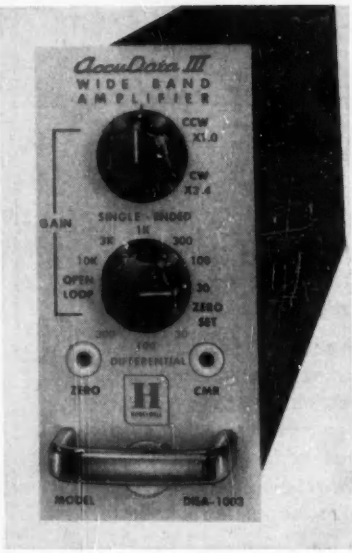
Testing Amplifiers for Zero Drift

Zero drift is measured at the amplifier output with a strip chart potentiometer such as the Honeywell ElectroniK Recorder connected through a low pass filter as shown. The amplifier input should be shorted. Equivalent input drift is the absolute amount recorded at the output divided by the amplifier gain measured under known conditions of temperature and line voltage, and, if necessary, for a specified time. There do not seem to be agreed-upon definitions of short or long-term time periods. For further details, write for Bulletin BE AN122.



Zero Drift Less Than 0.02 Per Cent at 10 mv

The AccuData III, Honeywell's all-transistor, wide-band, differential input, chopper-stabilized, d-c amplifier, has the lowest drift of any amplifier in its field — something less than 0.5 microvolts at reasonably constant ambient temperature, or less than 2 μv with a 10°F change in ambient. The effect of line voltage never exceeds 1 μv for a $\pm 10\%$ change, hence, under conditions most frequently advertised for amplifiers, its zero error with a 10mv input signal would be less than 0.02%.



The AccuData III has single-ended as well as differential input ranges, input impedance of 2 megohms differential (20 megohms single-ended), and power output sufficient to drive the highest frequency galvanometer oscillograph to its maximum deflection. In addition to excellent drift characteristics, the AccuData III offers exceptional linearity, very low noise, and frequency response to 20kc. Write for Bulletin BS-DISA-3 to Minneapolis-Honeywell, Boston Division, Dept. 00, 40 Life Street, Boston 34, Mass.

Honeywell

First in Control

SINCE 1885

Control ENGINEERING

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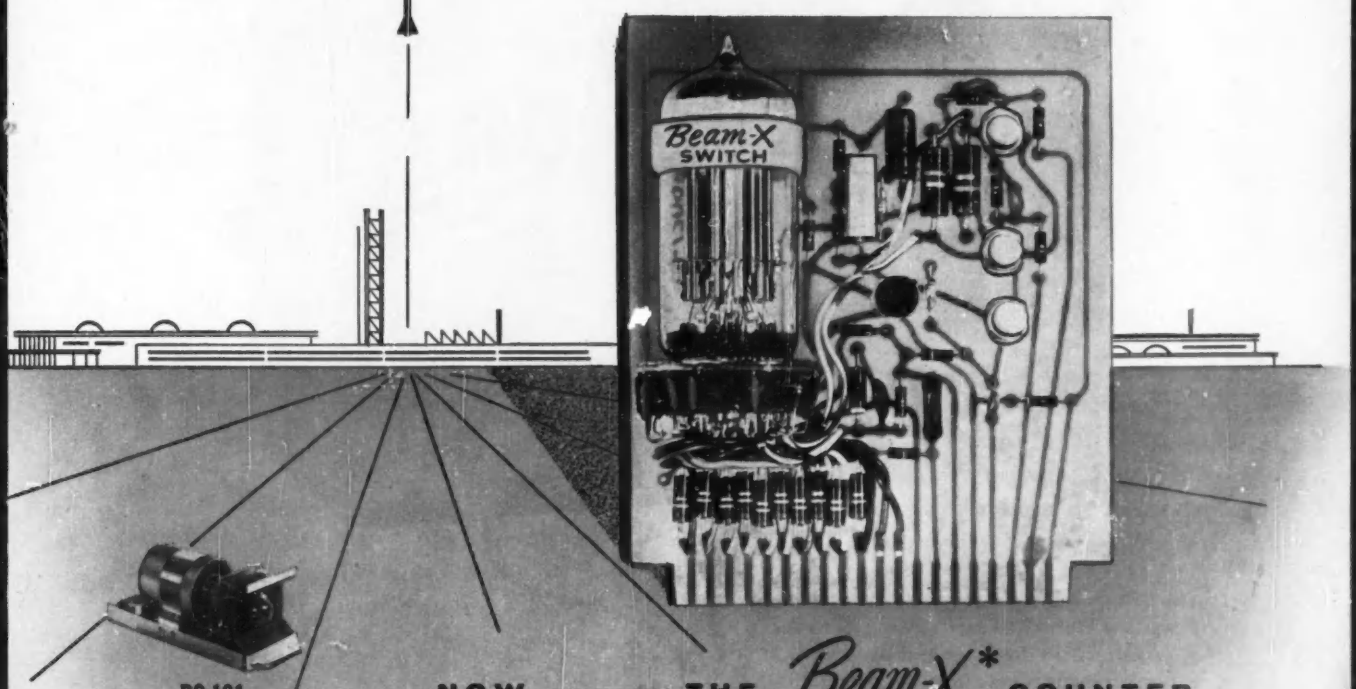
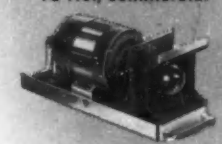
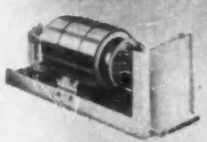


DC-101
10 Kc., commercial



DC-105
1 Mc., commercial



DC-106
100 Kc., commercial

DC-130
100 Kc., mil. spec.

NOW . . . THE *Beam-X** COUNTER

The new Burroughs **BEAM-X** Counter is the lowest cost transistorized decade counter available. The DC-111 Counter, newest product of the Electronic Tube Division, combines the Beam-X switch with transistors in a circuit capable of resolving pulses at 110 Kc. Electrical outputs are provided to operate remote Nixie® tubes, printers, and to perform other circuit functions. This latest addition to the Burroughs Counter line makes possible a number of advantages never before available:

- **Use of new Beam-X switch—lowest cost, lightest weight, highest speed, smallest size 10 position electronic counting device.**
- **Total power consumption of only two watts.**
- **Elimination of as many as ninety components from counting circuits.**
- **Increased reliability due to component reduction and use of the ultra reliable Beam-X switch.**

This counter is designed as a plug-in module for use in computers, electronic counters, machine control, automation and test equipment and military systems. The units may be directly cascaded. They can be driven by a twelve-volt signal, and are compatible with existing transistor logic circuits.

FOR DETAILED INFORMATION,
WRITE FOR BULLETIN 1002

ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

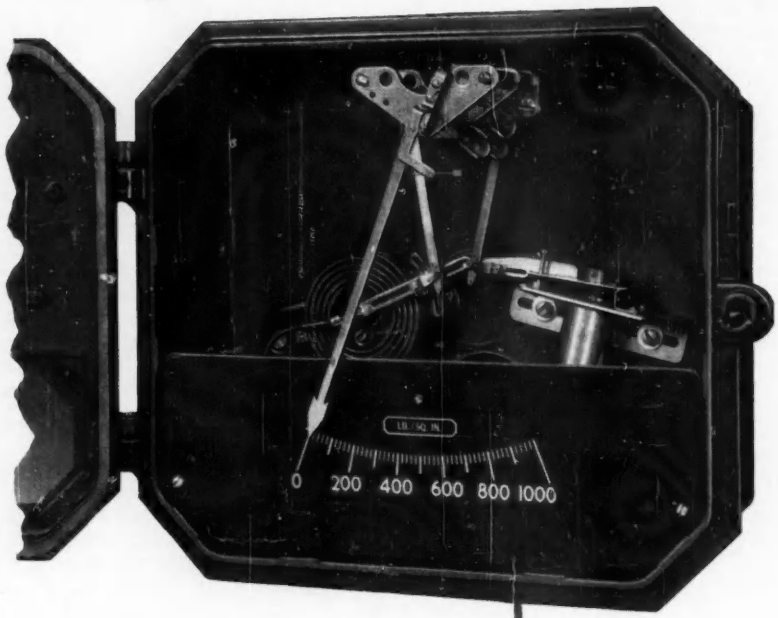
ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

* Trademark of Burroughs Corporation

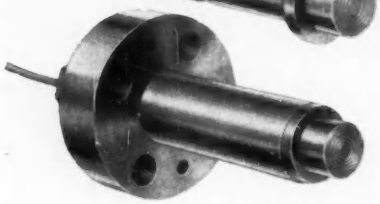
CIRCLE 7 ON READER SERVICE CARD

Better *Taylor* elements for

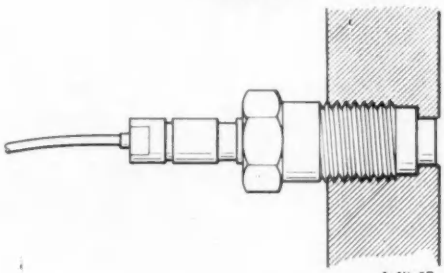


The "Button Diaphragm" Volumetric Pressure Element has a sensing head less than an inch in diameter and practically insensitive to process heat. It is available in three types of construction: *Type 90*—with rigid stem 5⅜" long and with grooves for jack-out collar; *Type 91*—same with flange built on system; *Type 92*—same with hub built on system. Capillary connection permits "off-press" location of the instrument. Type 90 shown here is connected to a Taylor 726T Universal Electronic Indicating Transmitter.

Type 90



Type 91



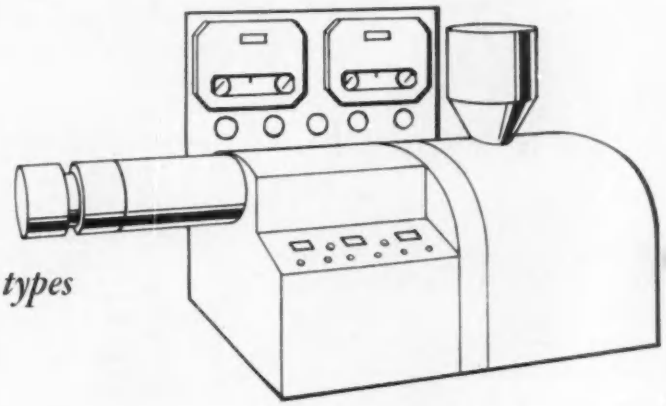
Type 92

A-411-27

Taylor Instruments

high pressure measurement

"Button Diaphragm" Volumetric Pressure Systems . . . *ideal for high pressure extruders of all types*



For high pressure measurement in the extrusion of synthetic fibres, plastics, films, etc., Taylor all-welded closed systems are far superior to anything previously used. The "Button Diaphragm" type shown at left has a sensing head less than 1" diameter. It is available in a variety of ranges from 0-400 psi to 0-15,000 psi. It gives accurate pressure measurement at operating temperatures up to 1500°F. It has these advantages:

Less sensitive than a strain gage to high process temperatures.

Eliminates troublesome leakage, due to sturdy welded construction.

Easier to install and maintain.

Systems are factory assembled, filled and calibrated, insuring accurate measurement and eliminating the necessity of filling and adjusting in the field. They can be used with any Taylor pressure indicators, recorders, controllers or transmitters having Bourdon spring actuation.

Taylor Volumetric Pressure Systems are also ideally suited for pressure measurement of difficult substances, such as slurries, corrosive fluids, colloidal suspensions or liquids that tend to jell in small pipes.

Ask your Taylor Field Engineer, or write for **Bulletin 98398.** Taylor Instrument Companies, Rochester, New York, or Toronto, Ontario.

Other types of all-welded volumetric pressure element available for pressures up to 1500 psi. Write for **Bulletin 98365.**

Fig. 1—Type 107

Fig. 2—Type 104

Fig. 3—Type 105

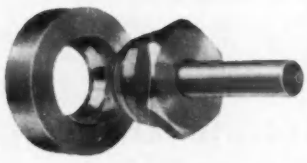


Fig. 4—Type 106

MEAN ACCURACY FIRST

The Story in Back of a Symbol

Begin with a coil for perceiving electrical changes. Add two arrows and convert sensing ability into action. Now, enclose in an ohm ... and you have the signature of the REGOHM® family. These controls, of pure simplicity and reliability, are being used in over a million individual applications throughout the world.

Consider one fast-rising scion of the family tree—the REGOHM Transducer. If you would like to make a mosquito move a mountain, the transducer will bring you close to the summit. A few grams of force causing less than ⅛ inch movement effects direct control at the ¼ kw level.

Performance like this can significantly reduce costs in many control systems: Position, Tension, Weight, Loop, Speed, Pressure and others.

ERC Engineers are ready to assist you with your application. To learn more about the REGOHM Transducer, contact:

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NORWALK, CONNECTICUT
"leaders in automatic control and regulation"

SHOPTALK

Catalogs, computers, and now consulting

Newly welcomed to CONTROL ENGINEERING's distinguished consulting editor ranks is Charles E. Faulkner (see page 19), computing center manager for Spiegel, Inc., the large Chicago catalog order firm. Charlie will advise on our coverage of his specialty, computers and information processing. He'll have a big hand in guiding the progress of our new information systems section, which starts this month (page 103). Our sincere thanks go to Dr. Eugene M. Grabbe, who has served as a consulting editor since CtE's start back in 1954.

Other new faces

Also new to our masthead this month is Mason P. Southworth (photo) who comes aboard as an assistant editor. Mason earned a BS degree from Trinity College and took honors as a BEE grad at RPI. After spending three years on an Air Force project to correlate radio propagation information received from amateur operators—work conducted both at the American Radio Relay League and at Stanford Univ.—Mason returned to the ARRL and has been a technical editor for outfit's magazine, *OST*. Still another addition is Caroline Taylor who comes from the *Journal of the Aerospace Sciences*; she becomes copy editor replacing Steve Livers who's moved up to assistant editor. Also promoted recently was Ed Kompass, now an associate editor in charge of Information Systems.

Bailey plumps for incremental servos

Though qualified by an impressively full background to comment on virtually any phase of servosystems engineering, Samuel J. Bailey has devoted lots of thought recently to incremental servos. Part of the results have been appearing in CONTROL ENGINEERING's definitive series on these devices; Part III appears this month on p. 85. Sam is now a senior systems engineer at Vitro Laboratories Div. of Vitro Corp. of America. In the 20 years since he completed his engineering training at Stevens Institute of Technology (both B.S. and M.S. degrees), Sam has had a chance to do almost everything in the servo field. Previous to his Vitro post he was with The W. L. Maxson Corp., Servo Corp. of America, Fairchild Camera and Instrument Co., Lawton Products, Mergenthaler Linotype Co., and Giannini Controls Corp.

For the first time—

a 30″ x 30″ plotter that repeats exactly from any position.

The unprecedented reliability and reproducibility of this new, automatic X-Y Plotter are the result of an entirely new engineering approach that has eliminated all servo drive systems.

As a result, the unit always repeats within ±.003″ as it moves from any direction to a previously plotted point.

Input is from IBM cards, punched paper tape or keyboard. In addition to its standard, 12-symbol print head, other print sectors can be installed to plot digital or symbol information.

Gerber's new plotter comes complete with keyboard, tape, and card input and facilities for setting scales on one X Channel and one Y Channel (additional Y Channels optional).

The most complete line of precision plotters

Engineers can now turn to just one source—The Gerber Scientific Instrument Co.—for all sizes of plotters that will display the most precise data that can be collected and reduced.

Along with its standard 11″ x 17″, 30″ x 30″ and 48″ x 48″ models, Gerber's new engineering concept makes it possible to incorporate this pinpoint accuracy into special plotters tailored to your needs. Write today for full details.

Specifications— the Gerber Model GP-30-C X-Y Plotter

Plotting Area: 31″ x 31″ (inquiries for other sizes invited)

Accuracy: to .05% of full scale; plotter will repeat from any direction within ±00.003″

Slewing Speed: 20″ per second

Plotter Inputs: IBM cards, punched paper tape, keyboard included as standard equipment

Printing Head: twelve symbols, any of which can be selected at random; additional print sectors can be added to plot digital as well as symbol information

Solid State: high reliability

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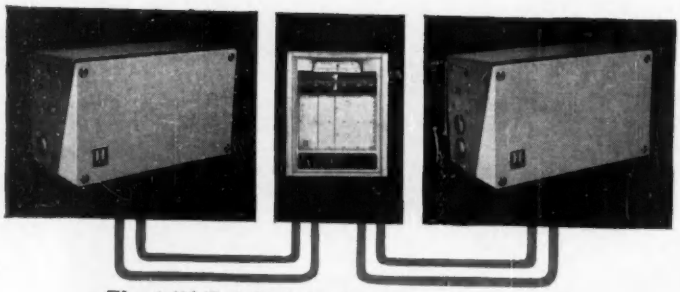
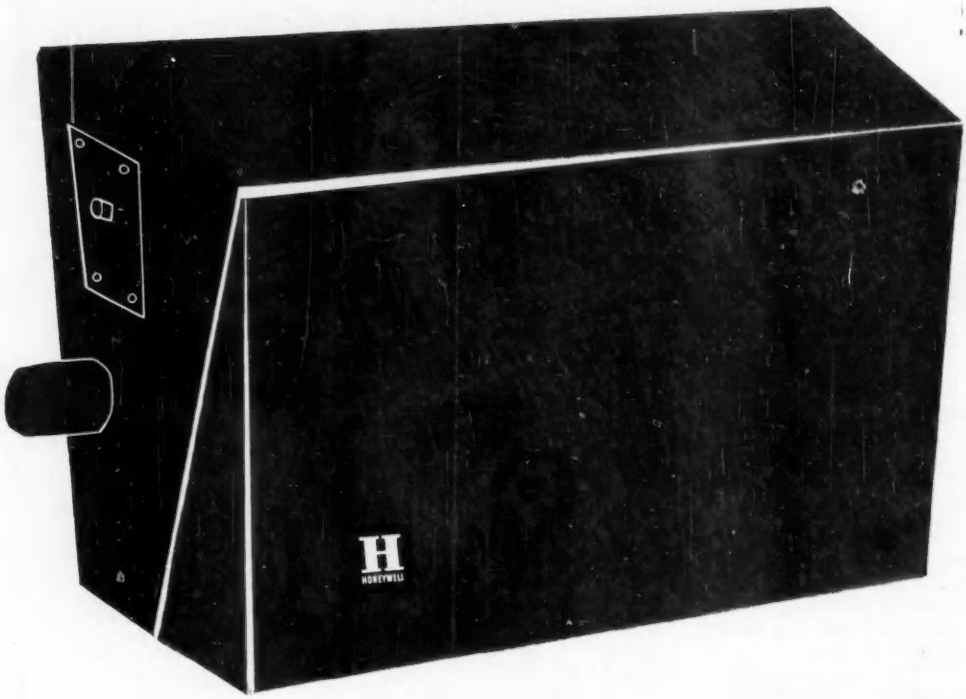
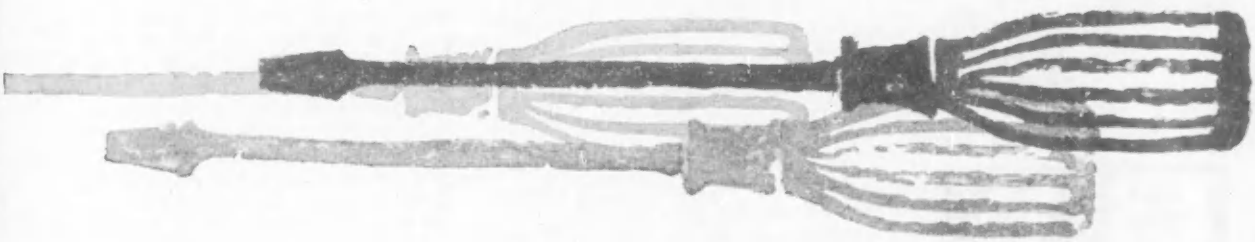
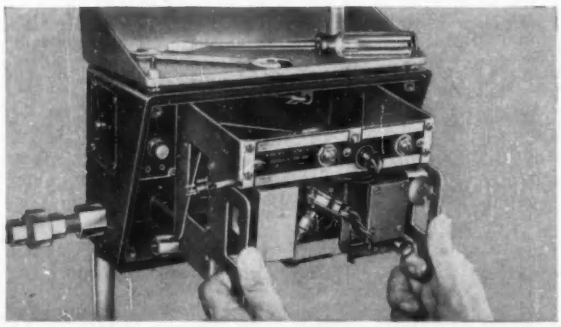


ElectriK Tel-O-Set—the true 2-wire system



NO STAND-BY SUPERVISION





No stand-by supervision needed when you install an *ElectriK Tel-O-Set* Control System. Installation crews never have to open an instrument cover to hook up the line . . . instrument crews never have to touch an outside line to service an instrument.

It's all in the *Tel-O-Set* connection system. All process connections are entirely isolated from the inside of the instrument case. Installation crews can mount, pipe, and wire the various *Tel-O-Set* instruments without removing the cover. Instrument chassis can be removed for servicing without breaking any external process or electrical connection. Standardized parts, together with extensive use of quick-connect and plug-in design, minimize downtime and reduce spare parts inventory.

And there's more to the *ElectriK Tel-O-Set* economy story. Specifically, there's no external power required at any field-mounted *Tel-O-Set* instrument. Line power connection is made only at the receiver. Two-wire d-c transmission reduces installation costs and eliminates shielding problems. Also, the 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. The d-c signal can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

Take a new look at your control problem with the *ElectriK Tel-O-Set* System in mind! Get the complete economy story from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

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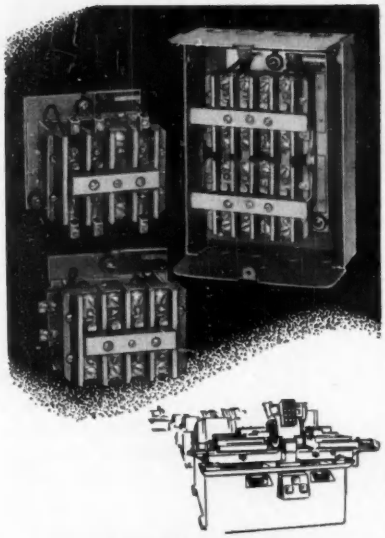

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Take a good look at the B/W line of magnetic and reversing contactors and you'll get a refreshing new concept of motor control quality and value.

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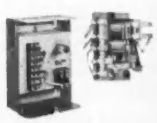
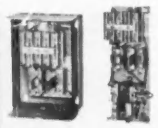


Induction Type & Electronic Relays



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FEEDBACK

This reader comments on origin and current applications for switching valve.

Here's more to the story.

To the Editor—

Mr. Morton Moore's article "The Acceleration Switching Valve Still Has Advantages" (June '60) very excellently summarizes the attributes and proven capabilities of this servovalve. The excellent performance under extraordinary environmental extremes is a direct result of making the valve an "ignorant brute" saturated either left or right with insignificant time expended in switching the flopper to the next state.

The author's comment that any valve can operate as a switching valve may prove disappointing. The larger flapper inertias and diaphragm forces associated with dry coil torque motor valves will preclude clean switching at 150 to 200 cps. This means that the torque motor parameters of force, nozzle position, flapper force field, and oil viscosity have time for their variances to be felt upon the valve during the transit period when the flapper goes from one nozzle to the other. The valve then becomes subjected to environmental conditions, which is not true of the switching valves made with the wet coil torque motor designs.

Mr. Moore also implied that it is possible to decrease the quiescent flow by spool overlap. This dynamically places a dead space in the valve flow-spool position transfer and could *and has* created low frequency limit cycle oscillations in experimental valves procured with overlap. A line to line spool bushing valve is definitely required here. The leakage flow equations derived have proven remarkably accurate, being within 20 percent of actual leakage flows when the flow necessary to move the spool at the switching frequency is taken into account.

The credit given John Chubbuck as inventor of this valve concept unfortunately does not cover the full story. Woodrow Seamone of the Applied Physics Laboratory of Johns Hopkins University was the hydraulic servo engineer who made this concept work in practice. Mr. Seamone pioneered the valve into the antenna servos of a currently flying antiaircraft missile system, pioneered its usage in very high temperature environments, and in driving resonant loads with servo bandpass equal to that of the load. Mr. Seamone was also associated with the development of this valve for primary flight control servos, which were unfortunately dropped due to a program cancellation.

Briefly, the readers of Mr. Moore's article might benefit from the fact that acceleration switching valves are currently flying, have been used on static firings of solid fuel rocket engines, and at high temperature environments of 800 deg F with oil as high as 550 deg F. They have also been used on an experimental milling machine with satisfactory results. It is certainly no longer a laboratory curiosity. Somewhere between 500 and 1,000 valves have been procured.

Gerald A. Levine
Corning, N. Y.

NOR off-the-shelf

To the Editor—

In the "Feedback" column of the August issue (p. 10), you have listed some companies who provide single modules of logic circuits. You overlooked International Resistance Co., which not only is in the business, but to date is the only manufacturer that offers a microminiature version of a NOR circuit that is available off the shelf.

A complete NOR circuit is only 0.4 in. square by 0.050 in. thick. Utilizing precision film techniques, these are particularly adaptable for adder, preamplifier, binary counter, and logic circuits.

Walter H. Canfield
International Resistance Co.
Philadelphia, Pa.

PERCOS Pot Percolates

To the Editor—

PERCOS seemingly begins to perk. I much appreciate your continuing to forward me requests for information received in response to your June editorial, "Could PERCOS Perk?" On each occasion I mailed out copies of the IRE paper and later followed up with a letter, asking for comments.

Some of these comments are most interesting. It turns out that large engineering organizations like General Electric, Westinghouse, RCA, and others are working internally on the

NEW FROM POLARAD—
UNIVERSAL SERVO ANALYZER .001 TO 100 CPS

MEASUREMENT	METHOD OF MEASUREMENT	INPUT TO SERVO SYSTEM	APPLIED TO SCOPE'S VERTICAL PLATES	APPLIED TO SCOPE'S HORIZONTAL PLATES	RESULTING SCOPE PATTERN Typical Response	RESULTING SCOPE PATTERN 0° Phase Shift
PHASE RESPONSE OF A-C SERVO SYSTEMS	Bowtie	50 cps to 6000 cps carrier, modulated at rate of 0.001 cps to 100 cps.	Modulated Return Signal	Low-Frequency Sine Wave		
	Double Bowtie	50 cps to 6000 cps carrier, modulated at rate of 0.001 cps to 100 cps.	Modulated Return Signal	15kc Reference Envelope		
	Sweep	50 cps to 6000 cps carrier, modulated at rate of 0.001 cps to 100 cps.	Modulated Return Signal	Linear Sweep	Fig. 5-a	Fig. 5-b
	Sweep	50 cps to 6000 cps carrier, modulated at rate of 0.001 cps to 100 cps.	Demodulated Return Signal	Linear Sweep	Fig. 5-c	Fig. 5-d
	Lissajous	50 cps to 6000 cps carrier, modulated at rate of 0.001 cps to 100 cps.	Demodulated Return Signal	Low-Frequency Sine Wave		
PHASE RESPONSE OF D-C SERVO SYSTEMS	Bowtie	Low-Frequency Sine Wave 0.001 cps to 100 cps	Sine Wave Return Signal	15-kc Reference Envelope		
	Double Bowtie	Low-Frequency Sine Wave 0.001 cps to 100 cps	Modulated Wave Return Signal	15-kc Reference Envelope		
TRANSIENT RESPONSE OF A-C SERVOS	Analysis of Returned Square Wave, Triangular Wave, Ramp, or Impulse Functions	Function with Carrier	Modulated or Unmodulated Return Signal	Linear Sweep	Square Wave, Triangular, Ramp, Impulse	
TRANSIENT RESPONSE OF D-C SERVOS	Analysis of Returned Square Wave, Triangular Wave, Ramp, or Impulse Functions	Function without Carrier	Modulated or Unmodulated Return Signal	Linear Sweep	Same as Figures 5a, 5b, 5c, and 5d, except without carrier. Waveshapes without carrier are indicated by heavy outlines.	
AMPLITUDE RESPONSE OF A-C SERVOS	Oscilloscope Calibration	50 cps to 6000 cps Modulated Carrier	Modulated Return Signal	Linear Sweep (if desired)		
AMPLITUDE RESPONSE OF D-C SERVOS	Oscilloscope Calibration	Low-Frequency Sine Wave	Modulated Return Signal	Linear Sweep (if desired)		

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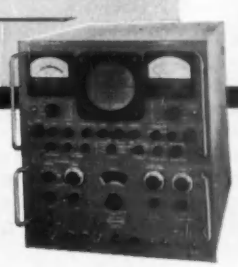
The new Polarad MODEL SV-1 SERVO ANALYZER is a complete instrument for testing AC and DC servo mechanisms in all applications. It combines a multiple precision signal generator and oscilloscope. Internally generated reference signals are compared with servo outputs and are displayed visually for quick servo analysis.



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WITH TRINITY THERMOWELLS

Trinity Thermowells fit right, work right and last longer. Made of certified materials to the most exacting tolerances in the industry, Trinity Thermowells are backed by a written guarantee accompanying each standard well.

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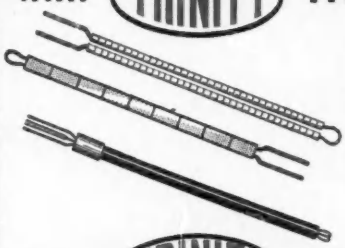

A complete selection of wire materials and sizes, welded to meet or exceed the industry's standards assure you accurate performance in every installation when you select a Trinity Thermocouple.

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Precise thermocouple assemblies sheathed in a protective well for miniaturized, or hard-to-reach points in a system or assembly. Also available in multi-point assemblies. Trinox is available in sizes down to .040" in diameter.

Start with the best, or replace with the best—to maintain top dependability in your system. No system is more dependable than any single component in it—and when it comes to thermowells or thermocouples, you're guaranteed the finest with Trinity...

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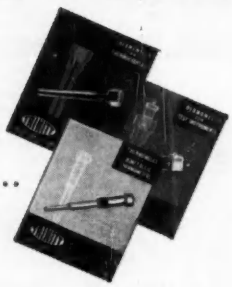

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FEEDBACK

creation of similar systems. Mr. Hutton, a consulting engineer of the Specialty Control Department of General Electric, for instance, writes, "The similarity between the classification listed under Class 1 and what we called Circuit Type is striking." Mr. Gue of Canadian Westinghouse visualizes wide spread use of PERCOS and writes, "The possibilities for adaptation and application are startling to say the least." Among other things he anticipates that the "familiar new-equipment journals which come around monthly will be substituted by a PERCOS-type card file system to which interested industries could subscribe."

Eugene Mittleman
Chairman, IRE Committee 10
Chicago, Ill.

Could mean an entirely new type of publishing service. Ed.

Will control patents affect us?

To the Editor—

"Newsbreaks in Control", page 17, July 1960 issue includes an item entitled "Patent Troubles for Numerical Controls". It refers to a situation in the machine tool industry, which may be troublesome to some builders because of basic patents.

We are working on a system for use in printing plants, which will make use of numerical controls to program a sequence of operations. Perhaps the patents referred to in your article will affect us as well as the members of the machine tool industry. Please send us information on this matter, including patent numbers.

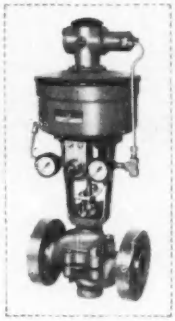
M. E. Oliphant
The Goss Co.
Chicago, Ill.

The requested patent numbers are:

2,352,183	Control Mechanism
2,352,184	Control Mechanism
2,352,185	Machine Tool
2,384,809	Machine Tool
2,427,493	Control Mechanism
2,511,821	Control Mechanism
2,528,736	Control Mechanism
2,536,624	Mechanical Movement
2,575,792	Control Mechanism
2,579,998	Lathe Control
2,623,970	Electrical Switch
2,694,116	Electrical Switch
2,859,290	Machine Tool Controller

You may also want to read a news story, "Will Bullard's Patent Claims Test Numerical Control?", pp. 54-56 in our September 1960 issue. Ed.

THANK YOU, COMPETITION!



Thank you control valve manufacturers. We see by your ads in the trade press and your exhibits at shows, that you are now offering split-body valves with cylinder actuators.

As most of you know, we have been manufacturing and marketing our Series LB split-body, cylinder-actuated valve for ten years. When we first started making the Series LB control valve—a radical departure from the then conventional double-seated valve with spring and diaphragm actuator—we did it because we sincerely believed it was the best way to control process fluids.

Those of us who pioneered the split-body, cylinder-actuated valve invested considerable time, money and effort in extolling its many features. As the years went by and user acceptance increased, we became stronger in our belief. However, there were many times during those years when we would have welcomed confirmation from you in the form of competitive products. Now, your announced entry into this field is, to us, a gratifying endorsement of the concept we have spent so much of our energies in developing. The added impetus that your collective advertising and sales efforts will give to publicize the benefits of the split-body, cylinder-actuated valve will contribute materially to its universal acceptance.

Although we know we have a good product backed by a decade of design and manufacturing experience, we do not intend to rest on our laurels. We will continue to offer industry the very best control valve we can make. And you will strive to outdo us. Your customers—and ours—and our industry—can only benefit from this healthy competition. Again, we thank you for following this lead in control valve technology.

CONOFLOW SUBSIDIARY WALWORTH

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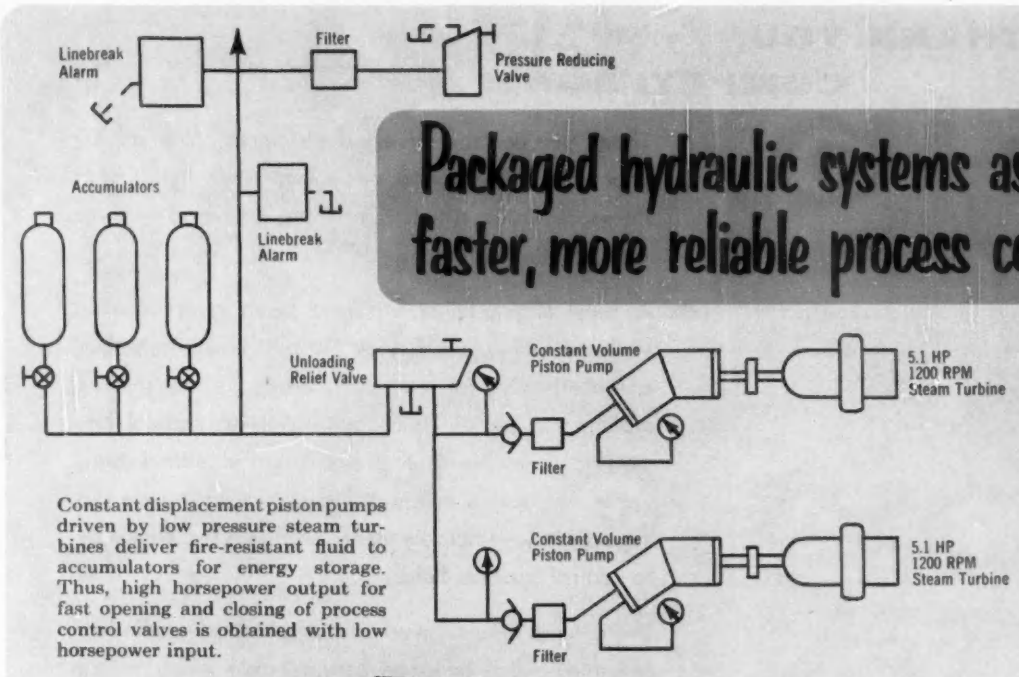
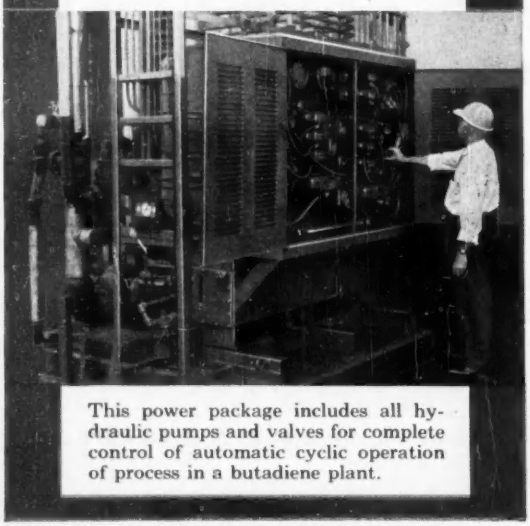
Packaged hydraulic systems assure faster, more reliable process control



Constant displacement piston pumps driven by low pressure steam turbines deliver fire-resistant fluid to accumulators for energy storage. Thus, high horsepower output for fast opening and closing of process control valves is obtained with low horsepower input.

Control console and power unit form electro-hydraulic system for controlling automatic heat treatment cycle. Physical layout provides optimum circuit efficiency, ease of servicing, and good appearance.



This power package includes all hydraulic pumps and valves for complete control of automatic cyclic operation of process in a butadiene plant.

Fast and precisely controlled motions, having the high reliability demanded by modern processing, are inherent characteristics of hydraulics. In addition, these advantages are obtained at low cost, for you can cover your full range of operations—from valve control to power transmission—with standard Vickers components. Your engineers enjoy unlimited design flexibility through a choice of electric, electronic, pneumatic and manual signals to control the hydraulic pumps, motors, cylinders, and variable speed drives.

Vickers complete packaged systems are ready to go into service upon arrival in your plant, since they are thoroughly pretested before shipment. They are properly designed and built to give maximum service life with little downtime, thus helping to keep your plant on stream.

Get more information on the job being done by Vickers packaged hydraulic systems in chemical, petrochemical, petroleum refining, and other processing industries by writing today for Bulletin I5802, "Packaged Hydraulic Systems for Process Control."

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9138

Charles E. Faulkner

Engineers Business Systems

With an IBM 7070 purring away down the hall, and four IBM 1401's on order, Charles E. Faulkner, computing center manager at Spiegel, Inc., in Chicago is reaching toward his goal of mechanizing the information handling procedures of a tremendous mail order operation. A work force that varies from 8,000 to 13,000 and a work load that exceeds 80,000 orders a day in the pre-Christmas rush make the Spiegel Chicago facilities the world's largest single mail order operation, an operation that would be inundated in paperwork and plagued by excessive time delays if it had not been for the foresight of the Spiegel management. Eight years ago they directed Charlie Faulkner to study mail order procedures from a systems point of view and to engineer business systems employing data processing equipment.

Faulkner's entry into the EDP field came via the "knows what needs to be done" route rather than through any formal training in computers or higher math. An economics degree from Dartmouth in the depression year of 1934 entitled him to a $22 a week job as industrial engineer at a Pawtucket, R. I., textile mill. Several years of time and procedure study duties at various textile mills culminated in a move to Spiegel in 1938 with the task of applying industrial engineering techniques to office operations—an assignment that turned into one of the early successful attempts to engineer business systems. The next 14 years were spent in studying and improving mail order business procedures. Duties such as supervising office operations, aiding in instituting an inspection department for operation quality control, and serving as expense controller for the merchandise division gave Faulkner the background necessary to "know his process".

The real break came in December 1952 when Faulkner convinced his management that the newfangled electronic computers might be of some use in keeping track of the vast Spiegel inventory. The results were twofold: an electronics research group to study the application of EDP to Spiegel operations, and hundreds of thousands of miles of travel by Faulkner to every nook and cranny where electronic data processors were on the blackboard, on blueprints or on the assembly floor.

The five years before Faulkner and his little group took delivery of their first computer—an IBM 650 in February 1958—were spent developing ideas, consolidating activities, bringing conventional accounting machine activities under their wing, and organizing a staff that today consists of 18 supervising systems engineers and programmers. Reporting directly to the financial vice-president, Faulkner and his staff have the authority to study an operation that looks promising and to make changes where these changes will benefit electronic processing. Thus he can take a long range look at the corporation as a system.

Practically since the time the 650 was installed, Charlie's staff has been programming for the IBM 7070, which arrived last October, and they are now getting ready for the delivery of four 1401's before the end of 1961. Some sort of record was made in putting the 7070 on the line; it was fully operating one week after delivery and the 650 was out of the computing center two weeks later.

As in any data processing application, getting information from the business system into the computer and from the computer back into the business system have been bottlenecks and Charlie has paid particular attention to these areas. At one time he invented and patented an electromechanical order filler, but soon found that the economics were off since the order filling cost is a small percentage of the total cost of processing an order—mechanizing the paper shuffling is where money can be saved. Since then he has patented a punched paper disc input medium for electric typewriters (to replace small paper tape loops that are hard to store), and he is now using wire links from remote catalog stores to simultaneously prepare the order, sales slip, and customer's address stencil in Chicago. Charles Faulkner's motto is to keep his eye on every piece of automatic data processing equipment on the market and use any or all if they'll help him to engineer a business system at a profit.

NOW

In the Model CM-100, Mincom's latest instrumentation recorder/reproducer, the series elements

THE MINCOM CM-100

before data storage have been reduced to recorder and mixer only, one step from the antenna.

IS PERFORMING

With the CM-100's 1-megacycle response and constant phase equalization at all speeds, an original

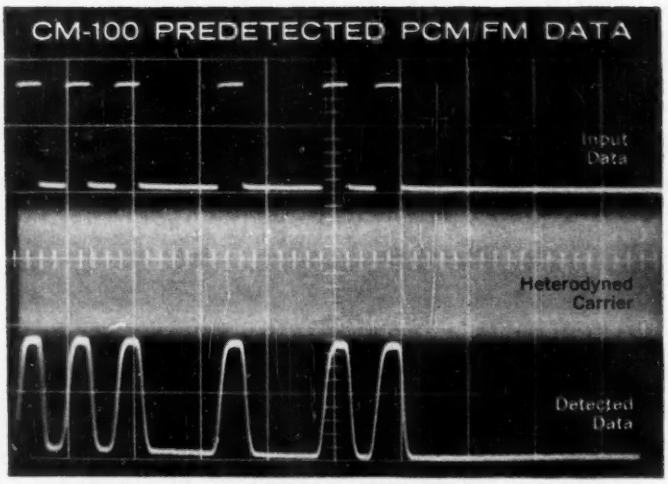
OPERATIONAL

IF signal of 5.0 megacycles thus can be heterodyned so that the carrier swing and its sidebands

PREDETECTION RECORDING

fall within the Mincom CM-100's frequency range – in FM, FM/FM modulation, PCM and PCM/FM.

...and actually doing it at defense facilities as you read this page.



5.0-mc IF carrier heterodyned down to 750 kc. Random-spaced pulses, 20 μs on-20 μs off-type information. Sweep rate: 50 μs/cm.

Write for brochure.

...WHERE RESEARCH IS THE KEY TO TOMORROW

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Newsbreaks In Control

● Numerical Control for Grinding Machine

Los Angeles—The first tape controlled contour grinding machine is being built to machine the ceramic portions of sparkplugs. At present the ceramics are machined by single point diamond dressers which have to be recontoured to tolerances frequently. The three axis numerical control system will do this automatically by withdrawing the tool from the worktable, recontouring its surfaces, and then returning the dresser to machining position. Cost of unit to be delivered in March: $36,000.

● Computer for World's Largest Steam Plant

Johnson City, Tenn.—World's largest steam plant, operated by the Tennessee Valley Authority, will soon have a process control computer to calculate operating guides. The project is the first successful venture of the association of Republic Flow Meters and TRW Computers Co. Republic will supply instrumentation and TRW will provide an RW-300 computer.

● British Banks Adopt U. S. Magnetic Character Codes

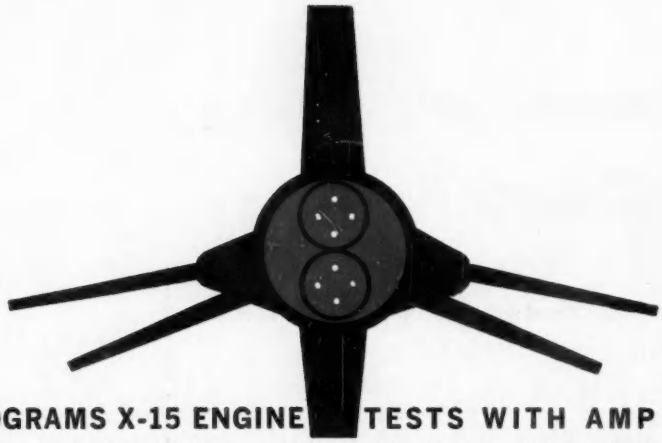
London—Clearing banks here have chosen to adopt American magnetic coding machine language for sorting checks with electronic readers instead of the "Fred" characters developed by Electric & Musical Industries Electronics Ltd. and the CMB type font pioneered by the French company De La Rue Bull Machines. The English banks are now ready to proceed with mechanization plans. Initial equipment will have to be imported from the U.S., giving a competitive edge to such suppliers as General Electric, IBM, Burroughs, National Cash Register—all of whom are already producing magnetic character recognition equipment.

● Hungary Claims Most Automatic Process Unit

Vienna, Austria—The Hungarian government has started what it claims is the most automatic distillation unit in Europe. With an annual capacity of 1 million metric tons, the unit, based on Russian blueprints, is being built at the Szoeny refinery. It is said to use a new type of pipe furnace that is automatically heat controlled with provisions for automatically checking quality and specific weights. Unit is to go on stream at the end of 1961.

● Computer to Process Transactions at Tokyo Stock Exchange

Tokyo—A Univac Solid State computer will handle the processing of transactions for the Tokyo Stock Exchange after January. The machine will handle about 60,000 transactions involving an average turnover of 150 million shares of stock per day. The exchange bought the computer for 154 million yen ($405,000).



Thiokol PROGRAMS X-15 ENGINE TESTS WITH AMP PATCHBOARDS

To test the 50,000 pounds of whoosh in its new X-15 engine, Reaction Motors Division of Thiokol Corporation required versatile and reliable programming systems to connect instrumentation to six different test stands. With the assistance of AMP engineers, Thiokol installed six patchboard programming systems that can connect one set of test instruments of any of six test stands with a flick of the wrist—a saving of time, personnel and equipment. In addition to tremendous flexibility, AMP systems—either universal or shielded—provide a number of exclusive features including pre-cleaning of contact pins and springs, rugged take-a-beating construction, an almost unlimited range of sizes, plus electrical characteristics suited to the most sensitive applications—all contributing to top notch reliability. **For the complete story, write for our Patchcord Programming Catalog.**

Reaction Motors' technician switches instrumentation from one test stand to another with a flick of the hand.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

British Optical Reader Suffers a Setback

LONDON—

First production model of the Solartron Electronic Group's optical reader was delivered to the customer, Boots Pure Drug Co. Ltd., last month—and was returned. A Boots' spokesman said that "recent policy decisions had largely rendered unnecessary the automatic reading and coding of cash register rolls, the job for which the reader had been ordered." But reliable sources feel that an inherent difficulty with the optical reading approach may have been responsible for the machine's return; human errors in recording the correct amounts on the rolls cancelled out the advantages of the machine.

During preliminary tests, a 10-percent human inaccuracy in making the initial entry combined with occasional substandard print quality to cause so many reading errors that manual intervention was required anyhow. Boots rejected one possible solution: changing all the company's cash registers.

The Solartron ERA (for Electronic Reading Automation) has an optical reading system in which a flying spot scanner is focused through a lens on the character to be read. As the spot image passes over the paper, more light is reflected by white paper than the printed characters. Reflections are picked up by a photomultiplier cell and converted to pulses which can be classified into one of 465 "cells" defined as black or white. Logic units then differentiate the characters, code them into a form suitable for further data processing.

Thin Film Memory in New Univac

ST. PAUL, MINN.—

First commercially available digital computer with a thin film memory was presented here last month when Remington Rand Univac announced the 1107 computer, the latest in the 1103, 1105 scientific computer line. In addition to incorporating the so-called third generation storage device, the 1107 is completely transistorized, a feature which its ancestors did not have.

The thin film memories—dots of very thin permalloy, vacuum deposited on a thin glass plate—are used in the control and arithmetic storage only, with 128 words of 36-bits available in 16 arithmetic and 15 index registers.

Main storage is 8,000 to 64,000 words of ferrite core storage. Memory cycle time in the core storage is 4 microsec—compared to only 0.6 microsec for the thin films. Basic addition speed is 0.8 microsec plus access time. Rem-Rand also announced a real-time control computer last month. Called the 490, this machine is a commercial redesign of the Navy's tactical data system which the company produced. With its 28 input-output channels and up to 32,000 words of storage, the 490 is intended for inventory and production control applications, processing bank deposits and withdrawals, and airline reservation systems.

Two Hundred Papers at Temperature Symposium

COLUMBUS, OHIO—

Most comprehensive meeting ever held on the subject of temperature measurement is scheduled for Columbus, Ohio, on March 27 to 31. About 200 papers, covering temperature measurements from absolute zero to 10 million deg K., will be presented by authors from all over the world. In addition to American speakers, the meeting will feature scientists from Australia, Germany, the Netherlands, Soviet Russia, and Great Britain.

The enlarged scope of the meeting indicates an awakened interest in temperature measurement in applications that range from the human body to process control and aerospace. The symposium is the fourth held on this subject: the first was in 1919, the second in 1941, and the most recent in 1954.

Does Industry Want Russian Abstracts?

WASHINGTON—

U.S. Dept. of Commerce Office of Technical Services is attempting to determine if U.S. industry wants English abstracts of technical articles appearing in journals of Soviet bloc countries and mainland China. The new series would be disseminated once a month on an experimental six-month subscription basis. Abstracts would appear from 70 to 120 days after the original.

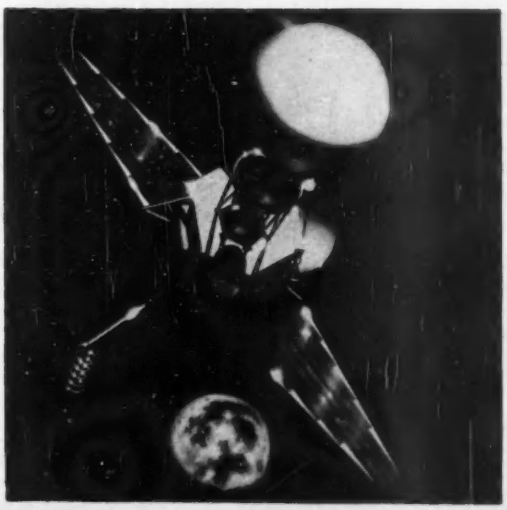
OTS has set up six major classifications of material and a subscriber may buy one or more of them.

Of prime interest to control engineers are: category 4, engineering machinery and equipment (including mechanical, electrical, aeronautical, nuclear, petroleum, structural, and civil) and category 5, communications, transportation, navigation, electrical and electronic equipment, systems, and devices including aircraft and missile equipment. Cost of each service is $9 for the experimental six-month subscription.

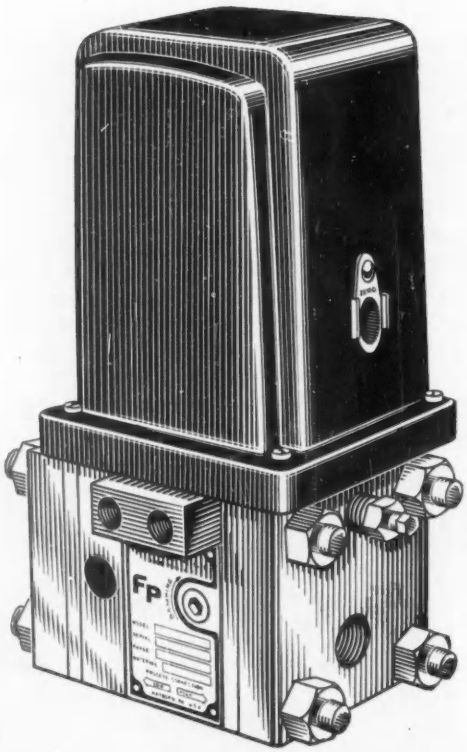
Interested subscribers should contact Office of Technical Services, Dept. of Commerce, Washington 25.

Lunar Probe Readied

The startling-looking vehicle at the right is the final design of the 300-lb lunar capsule being built by Ford Motor Co.'s Aeronutronic Div. for the National Aeronautics and Space Administration. The bulbous lunar capsule, with its retrorockets for deceleration on landing, is attached to a Ranger spacecraft which will carry it to the vicinity of the moon. The bulk of the capsule's payload will be telemetry gear and instrumentation to transmit information on key physical parameters, such as temperature, pressure, atmosphere composition, and radiation, back to earth.



■ This DP Transmitter is as close as anyone has come to the perfect process instrument. It performs every function a differential pressure transmitter *can* perform . . . dependably and competently. Every potential of an elegant and original design has been realized in the manufactured product. For example: adjustable damping in the differential sensing system lets you measure pulsating flow without zero shift, phantom signals, diaphragm fatigue, or premature part failure. A sealed measuring chamber filled with silicone oil is positively isolated from destructive process fluids. And the entire instrument is ruggedly constructed to take a beating and remain accurate and responsive. This, then, is an instrument you can install and forget. It has yet to betray a user's confidence.



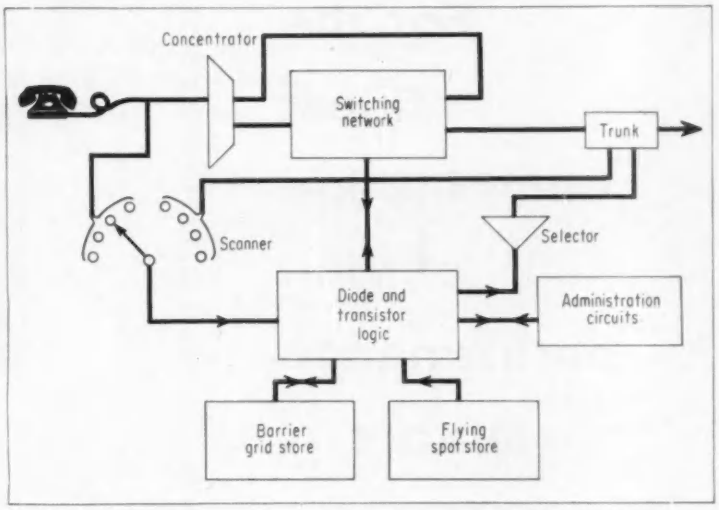
Every fact you could desire about our DP transmitter can be found within the covers of our Catalog 10B1465. But nothing can ever take the place of an actual field trial. We'll gladly arrange one for you.

Fischer & Porter Company,
711 County Line Road, Warminster, Pa.

Fp
FISCHER & PORTER COMPANY
COMPLETE PROCESS INSTRUMENTATION

Electronic Telephone Switching Debuts

Bell's prototype system uses programmed computer to transfer incoming calls automatically and complete calls with only two-digit dialing. Instruction for these and other regimes is stored in flying spot scanner. Barrier grid memory stores temporary data.



Switching system for first ECO shows how call gets on a trunk line.

MORRIS, ILL.—
While there are few places left in the United States where dialing "Central" is the necessary prelude to completing a telephone call, there is no other exchange that can compare with one just opened in this small town 75 miles from Chicago. It is in Morris that Bell Telephone Laboratories has chosen to try out its electronic central office (ECO).

• **New services**—The 319 Morris subscribers participating in the first phase of the trial now can do four unusual things with their telephones: dial a two-digit code which transfers all subsequent incoming calls to another number (call transfer); reach frequently called numbers by dialing two digits instead of seven (abbreviated dialing); have incoming calls routed to another phone when the original number is busy (series completion); and use home extensions as intercoms by dialing two code digits (extension code ringing).

Later on the service will be expanded with two more features: a third party may be called into an existing conversation by dialing a code number and the phone number (conference call); and an immediate connection may be made to a busy line as soon as it becomes available (busy clamp-on).

Behind these special services is a large scale computer. The major design difference—aside from the use of electronics—between the Morris ECO and other exchanges involves stored logic in a central memory. In older exchanges system logic is scattered throughout the circuit. In ECO it is retained in a flying spot store.

• **Photographic memory**—The flying spot store contains the entire operating program, written in the form of 2¾ million bits on four glass photographic plates, each divided into 17 storage areas. Each bit is represented by the presence or absence of a 0.006-in. diam dot in the photo emulsion. A cathode ray tube, an optical system, and a photomultiplier tube bank read all 68 storage areas simultaneously, though not more than 26 areas are actually used for any one logic operation. Two of these flying spot storage systems are used for reliability.

To interrogate the flying spot store, 68 lens systems image the CRT beam onto each storage area. Eighteen additional photographic areas and photomultipliers continuously measure the position of the flying spot. A circuit compares the actual position of the spot with the desired position, and feedback positions the spot to within 0.001 in. of the desired position—within 1 microsec.

The other two principal components of the Morris system's three-part main control are a barrier grid temporary memory and a central control logic network. The barrier grid store is divided into four sections, two for operation and two for standby. All are kept up to date, ready for instant switchover in the event of trouble. Each store will record 16,384 bits; read-write time is 2.5 microsec.

The central control logic consists of four cabinets containing nearly 3,000 germanium transistors and 20,000 diodes, all mounted on 3,400 plug-in printed circuit cards. The central control connects to every other unit and has the function of processing and routing control orders. It interrogates the semipermanent flying spot store for instructions; uses the temporary memory for recording the status of calls and lines; and controls the operations of scanners, selectors, and the switching network. Again, for reliability, two complete central controls are provided.

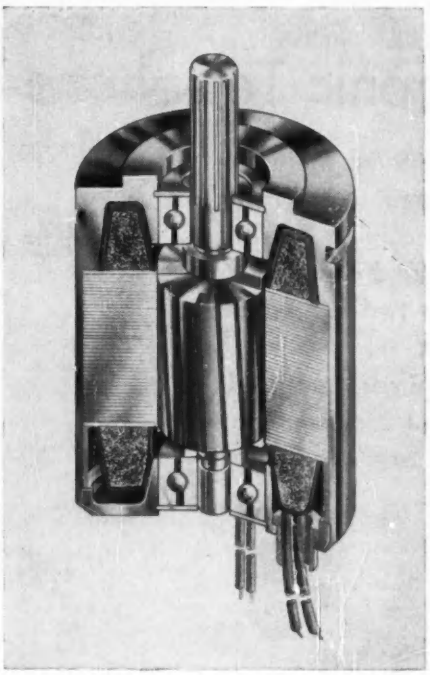
• **Gas tube switches**—The switching network and its associated connectors use gas tubes as switching elements. The network must keep pace with command signals, but it need not be as fast as the controls themselves.

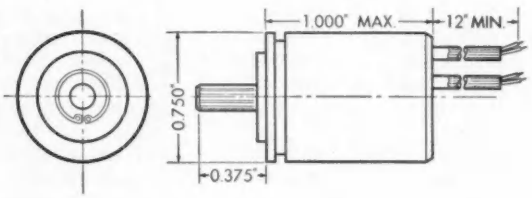
The gas tubes contain an anode and a photocathode in a neon filled glass envelope. The tubes are illuminated with blue fluorescent lamps to insure fast, reliable firing. Firing current is 10 ma at about 100 vdc; the small ac voice current modulates the dc passing through the tubes. The ECO at Morris uses 23,000 of these gas tubes, arranged in six switching stages plus a connector stage. A typical call passes through eight tubes.

The Morris ECO is not Bell's final approach. The Bell System's manufacturing subsidiary, Western Electric Co., will not begin production until mid-1965, leaving plenty of time to incorporate changes suggested by experience gained during the tryout.

For the finest combination of vital performance factors...

Specify KETAY Servo Motors





Performance and reliability in the size 8 servo motor, for example, is underscored by:

- Unexcelled ratio of stall torque to power input at maximum rpm, as related in the chart below.
- High acceleration at stall.
- Efficient operation over the ambient temperature range of—55°C to +125°C.
- Superior "white room" manufacturing, assembly and inspection techniques.

TYPICAL PERFORMANCE CHARACTERISTICS

Type Number	008E2A	008E2C	008E2D
Excitation Frequency (cps)	400	400	400
Rated Voltage:			
Fixed phase (volts)	26	26	26
Control phase (volts)	26	40/20	26
Input Power at Stall (watts)	1.75	1.75	2.50
Starting Voltage (volts)	0.68	1.0	0.68
Stall Torque (oz. -in.)	0.22	0.22	0.30
Ratio Stall Torque to Total Power Input	0.060	0.060	0.060
Rotor Inertia (gm. cm^2)	.414	.414	.414
Acceleration at Stall (rad./$sec.^2$)	36,000	36,000	53,000
No Load Speed (rpm)	6,500	6,500	6,500
Temperature Rise at Stall (°C)	50	50	60
Operating Temperature Range (°C)	−55 to +125	−55 to +125	−55 to +125

For more information on these or any other of the complete line of Ketay Servo Motors and/or motor generators from size 08 to size 23, 26 or 115 volt, 400 or 60 cycle excitation.

NORDEN

Ketay manufactures a complete line of precision synchros, servo motors, resolvers, motor tachometers, gyros, amplifiers and encoders in a wide range of sizes to meet your specific requirements. Components are available separately or in modular packages.

UNITED AIRCRAFT CORPORATION
NORDEN DIVISION
KETAY DEPARTMENT, COMMACK, LONG ISLAND, NEW YORK

Computers Set to Guide Oil Operations:

1 Socony's 7090 program will tell company what crude to use, what products to refine, and how to ship them to markets.

NEW YORK—

Can a computer run a huge business enterprise? Evidence that it can came closer last month when two oil companies announced plans to use computers widely Socony Mobil Oil Co. will use its newly acquired IBM 7090 to form the nucleus of a business forecasting scheme. Standard Oil of California has a computer network to solve operating problems (page 30).

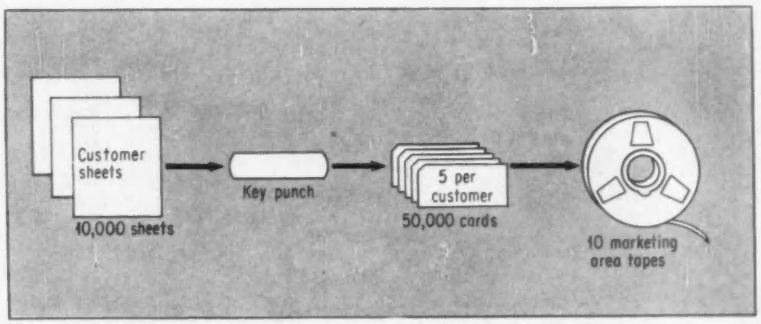
Socony already has tied together its Paulsboro (N. J.) and Dallas research centers and its Beaumont (Tex.) refinery with its New York computer center by data transceiver links. But as outlined by the center's manager, Dr. J. A. Aronofsky, the oil company will have a computing capacity by 1965 of one major computer (monthly rental: $65,000), five large computers ($10,000-25,000) and 50 small computers ($3,000-7,000). These will connect to 50 widely scattered Teletypewriter input terminals throughout the country.

The 7090 will fill the major computer slot, and Socony already has 10 IBM 1401's on order, scheduled for 1961 delivery, to fill out the system.

• **Planning product flow**—First job for the computer net—solving the product supply and distribution problem—is in the programming stage. The computer will consider all alternatives possible for delivering to 10,000 markets the 12 light-end products from 12 refineries, each refinery being supplied with crude oil from a number of fields. The task: figure out from what crude supplies to refine what products and where and how to ship them—and do this considering all operating factors, restraints, and individual costs.

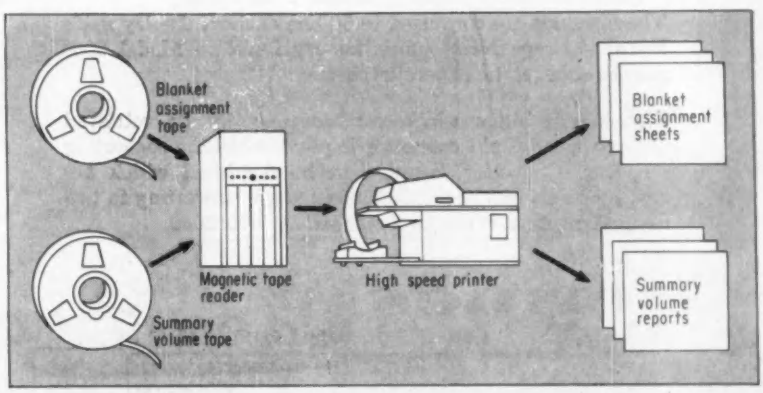
Starting from a written estimate of annual requirements by product for each customer, the computer system produces for each customer a product-by-product tabulation of the demand, the terminal or refinery from which each product will be shipped, the freight method, transportation rate, laydown cost, and total cost.

The same data are reanalyzed by the computer to produce a volume summary report, the annual product-by-



Petroleum customer estimates are converted to marketing area tape files. Then . . .

. . . 7090 determines lowest-cost customer, refinery product assignments. And . . .

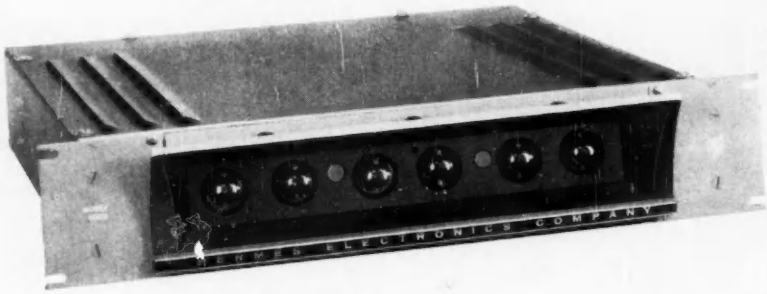


. . . customer report tabulates product demands, shipping data, and costs.

NEW!

Solid State

DISPLAY ASSEMBLY



for decimal display and storage of binary coded decimal data

accepts up to 24 bits of parallel BCD data

Hermes' new Solid State Display Assembly, Model 2060, is designed for use in any system requiring presentation in decimal display of a BCD parallel signal. For example, Model 2060 permits direct reading of Angular Shaft Encoders with BCD parallel output. Model 2060 accepts up to 24 bits of parallel BCD information in any of the following 4-bit Codes: Binary Code Decimal (1-2-4-8); Gray Code (Cyclic Code); Decade Counter Code (1-2-2-4) or (1-2-4-2); Binary Complement Coded Decimal; Binary Two Out of Five Code; Binary (1-2-4-7).

These signals are converted to 60-line decimal display using Burroughs-type Nixie tubes. Binary input to Model 2060 may be either static or parallel pulses.

Storage capability which can conveniently be retrieved through a multi-pin connector is provided in the converting circuitry. Converter Boards can be furnished which accept up to six bits of parallel information, converting to two decimal displays. *Write for Technical Bulletin 2060.*

Hermes

ELECTRONICS CO.

75 CAMBRIDGE PARKWAY, CAMBRIDGE 42, MASS.

A DIVISION OF Itek

product demand for each refinery.

• **Performance proven** – Aronofsky has good reason for feeling that this plan for forecasting light products distribution operations will work out well. For one thing the company has already established and proved throughput and yield-pattern models for each refinery. For another the computer-directed distribution idea was tried out last year on a smaller scale, using Socony's IBM 704 computer and its 4,000-market Midwest Div. as a proving ground. Staff and line personnel learned a lot from this trial, enough to convince Socony's management that the cost of preparing the larger program, acquiring data, and using the 7090 can be more than returned through better allocation of refining and transporting facilities.

The 4,000-market problem took 10 hr to solve on the 704. The 10,000-market problem is much more complex, but the higher speed of the 7090 will offset this, again resulting in a 10-hr computer solution which will optimize annual product distribution plans and print out assignment sheets for the 10,000 customers.

• **Geography helps** – The model should contain over 10,000 simultaneous algebraic equations. Actually, however, no computer presently exists –according to Aronofsky–that can come up with a solution to a problem of such magnitude in a reasonable time. Although theoretically each alternative solution must be tested against all other possibilities, certain conditions enable the model to be broken down into 10 smaller ones.

For instance, because no pipeline crosses the Rocky Mountains, there is little interaction between Pacific Coast and midwest operations. These regions can be considered separately. When necessary, however, the computer can determine how a refinery assigned to supply one marketing area might influence another.

• **Frequent interrogations**–Once the programming of the 10,000-market, 12-refinery model has been completed, it will be used first for annual forecasting. When changing conditions occur, only these need be modified in the program and data tapes. Aronofsky thinks it feasible to update and interrogate the 7090 once every three months and eventually monthly so management can shift plans accordingly.

A big advantage of having such an elaborate model is its capability for new business forecasting. It is possible to "add" a fictitious refinery or terminal and then predict what benefits can be achieved.

NO EQUAL IN SIMPLICITY!

ONLY 3 MOVING PARTS IN ASCO 3-WAY SOLENOID VALVES

Millions of Trouble Free Operations . . . are the result of the simplicity designed into ASCO 3-way solenoid valves. Fewer wearing parts mean substantial savings in maintenance costs . . . reduction in down-time losses.

Simple in construction, ASCO 3-way solenoid valves are simplicity itself in operation—solenoid piloting of two simple diaphragms. Absolutely tight seating is a feature—no closely fitted parts or valve seat grinding are required.

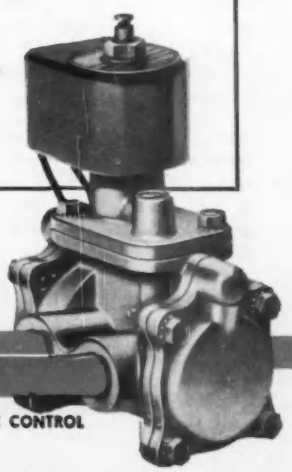
Exceptionally large flow capacity permits rapid filling and venting of cylinders . . . valves operate up to 400 cycles per minute.

Conversion from normally open to normally closed —or the reverse—takes just 30 seconds; only simple rotation of the valve bonnet required.

ASCO 3-way valves can be supplied with general purpose, water tight or explosion-proof enclosures, and may be mounted in any position. Valves are available in ⅜", ½" and ¾" sizes, all with full flow capacity provided by oversize pressure and exhaust orifices. Standard Bulletin 8316 Valves are suitable for air, gas, oil and water at pressures up to 250 p.s.i.; higher pressures can be handled by modified versions.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery . . .
World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.



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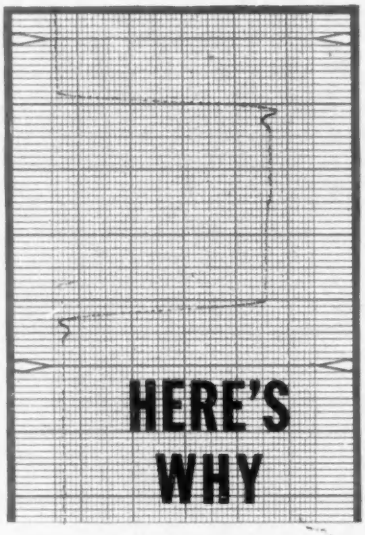
ASCO Valves Automatic Switch Co.
50G HANOVER ROAD, FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 29 ON READER SERVICE CARD



AO TRACEMASTER'S CARBON TRANSFER METHOD PRODUCES BETTER RESULTS!

The AO Tracemaster 8 channel recorder uses a direct-carbon-transfer writing method...clearly the best of all methods. The trace above, reproduced from a Tracemaster record, shows why!

Chart speed was 500 mm/sec. (Twice as fast as any other recorder). The trace is a gate pulse out of an Analab oscilloscope. Gate rise time is approximately 50 micro seconds. An amazing performance! Note the fine quality of the trace... the consistency of line through the entire band pass.

The direct carbon transfer technique makes this possible... mylar-backed carbon positioned between the stylus and the chart paper acts as an excellent lubricant. Stylus tip radius is smaller to produce a finer trace...yet there's no danger of "plowing". And it permits use of stylus pressure *5 to 7 times higher than with any other recorder* (velocity feedback signal out of the pen-motor applied to the linear driver amplifier makes the system much less susceptible to the effects of stylus pressure). This renders the system immune to ordinary shock and vibration stress... there's no ink splatter... little or no skip... no paper-tear.

Learn, in detail, all the advantages of the AO Tracemaster and its direct carbon transfer recording method. Send for complete literature. A request on your company letterhead will bring you an actual sample of an AO Tracemaster record.

American Optical Company

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2 *Stancal's 7090 is tied to refineries and development laboratories for a variety of data processing jobs.*

SAN FRANCISCO—

Across the country, a computer net supplies round-the-clock data processing services for the world-wide operations of Standard Oil of California. Stancal has linked its subsidiary California Research Corporation's LaHabra and Richmond (Calif.) development laboratories and three refineries—at Richmond, Calif., Perth Amboy, N. J., and El Segundo, Calif. —to an IBM 7090 computer at company headquarters in San Francisco through leased telephone lines. Eventually Stancal hopes to tie in its 35 major operating divisions.

One of the major jobs of the computer net at present is obtaining information and experience for future closed-loop computing-control of refineries to be accomplished eventually with local process control machines. The network puts a large scale computer in the hands of researchers at key spots in Stancal's operations throughout the United States.

• **Open loop**—For example, the El Segundo refinery has a fluid catalytic cracking unit which is being operated on open loop control by the computer. Readings of temperatures, flow rates, pressures, and stream analysis data are automatically transmitted to computing headquarters every 72 sec. The computer figures best valve and controller settings and transmits instructions back to the unit operator.

A problem in refining operation might come from any refinery or a development laboratory. Mathematicians have reduced all of the refinery operations at each location to mathematical models which are stored at computer headquarters. Thus the center has background for problems on existing operations. When one comes in, the questioner need transmit to the computer only proposed or actual changes. If a radically new problem is to be solved, a new model has to be constructed, of course.

• **Ask for service**—Here's how the Stancal net works. When a technician at a network-served facility wants to use the computer he sends a request for service to the center over the leased line. If a transceiver is free, the line is cleared for data transmission. The problem originator, who has already reduced his problem to punched cards, starts sending. In San Francisco, his carded information is duplicated on card blanks, thus supplying a buffer in case the computer is not free. A fail-safe device in the transceiver automatically checks each pulse, and the transmission is stopped if a mistake is made. When the computer is open, the problem is entered and solved. The output data are reduced to punched cards for transmission via transceiver to the originator.

Prior to establishment of the network, communication between the computer center, which was established in 1957 with an IBM 704, and distant operations was carried on by mail. Operations not on the network still communicate in this manner, and up to four days is often the minimum period between question and answer. With the network it can be a one-hour proposition.

"A major capability of the system", says H. W. Crandall, manager of the computing center, "is the solving of a fast-breaking situation while it is still in progress, rather than having to wait and do a post mortem. Similarly, complex computations have been made and intelligence transmitted in time to help negotiators reach important leasing decisions even during the course of negotiations."

In another type of problem, a refinery technician can determine precisely how his over-all operation will be affected by delayed or inadequate delivery of a single item. A frequent decision that refinery management has to make is which crude oil to buy at various prices, and which chemicals and special equipment to use. Availability of a computer enables better optimization of inventory and operation—that is, selection of the least expensive additives, adding minimal relative amounts, and still meeting product specifications.

Demands for computer time are growing as refinery operators learn what can be done with the net. The computer center has so far found that a "random" basis of operation is most efficient; most problems, especially the short ones, can be put on the machine at the first available gap in its utilization, usually the same day. For longer problems, however, time is booked in advance, a relatively simple matter requiring a letter, phone call, or voice explanation over the leased line. Each user is logged, and departments are assessed for their usage.

A GIANT RADIO HIGHWAY IS PERFECTED FOR TELEPHONY

A radio relay system operating at 6 billion cycles per second and able to transmit 11,000 voices on a single beam of microwaves—several times as many as any previous system—has been developed at Bell Laboratories. Utilizing the assigned frequency band with unprecedented efficiency, this new, heavy-traffic system was made possible by the development and application of new technology by Bell Laboratories engineers and scientists.

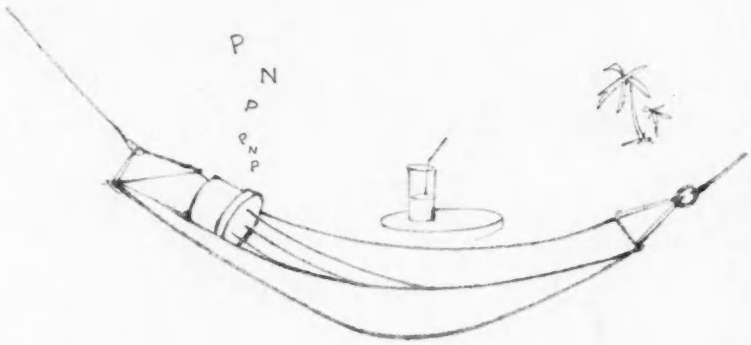
For example, they arranged for the waves in adjacent channels to be polarized 90 degrees apart, thus cutting down interference between channels and permitting the transmission of many more telephone conversations in the same frequency space. They developed ferrite isolators to suppress interfering wave reflections in the waveguide circuits; and a new traveling wave tube that has ten times the power handling capacity of previous amplifiers and provides uniform and almost distortionless amplification of FM signals. They devised and applied a new high-speed diode switching system which instantly switches service to a protection channel when trouble threatens.

To transmit and receive the waves, the engineers applied their invention, the horn-reflector antenna. Elsewhere, this versatile antenna type is brilliantly aiding space communication research in the reception of radio signals from satellites. For radio relay, a single horn-reflector antenna can efficiently handle both polarizations of the 6000 megacycle waves of the new system; at the same time it can handle 4000 and 11,000 megacycle waves used for existing radio relay systems. Thus it enables all three systems to share economically the same radio towers and routes.

Produced by the Bell System's manufacturing unit, Western Electric, the new system is now in operation between Denver and Salt Lake City, and will gradually be extended from coast to coast. This new advance in radio technology is another example of how Bell Telephone Laboratories works to improve your Bell communication services.

BELL TELEPHONE LABORATORIES

World center of communications research and development



taking the overload off

The trouble with using fuses to protect transistors from short period overloads or fault currents is simple: the transistor is by far the better (and faster) fuse. It can also be called too much "thermal inertia" on the part of the fuse, but the transistor still ends up the same way.

As fate* would have it, a prominent relay manufacturer has now come to the rescue. We've devised a simple little 3-terminal device that will prevent destruction of transistors by DC overloads. It's working in customers' equipment, and

- — operates in 1 to 5 milliseconds
- — limits the transient, with a complete short circuit, to a maximum of 5 times the set value
- — interrupts currents up to 5 amperes
- — can be reset (locally or remotely) or designed to cycle
- — will operate a local or remote warning light, buzzer, etc.
- — can be supplied in a wide variety of set points
- — operates within +20% of its set point
- — doesn't cost all outdoors

*and our New Business Program

You do have to allow for the resistance this overload protector introduces into the circuit, but it's in the order of 1 to 5 ohms and the voltage drop is a few millivolts, less than one-tenth the voltage drop of the conventional circuit breaker.

To those who might question the economics of spending more than the transistor's cost just to protect it, keep the alternatives in mind. If the burned out transistor(s) lets a machine produce a carload of 4-foot yardsticks or causes a few hours of expensive down time, the protection is cheap. (Ever rented a computer?)

If you'd like some block diagrams of typical uses and an assortment of representative values and ratings, write to us, care of our Current Fault Division.

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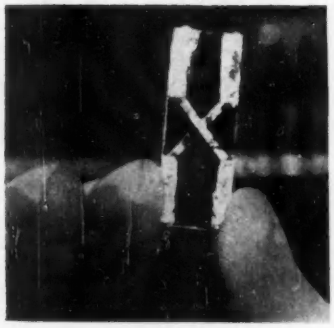
WHAT'S NEW

Cold Tunneling Device is Newest Component



A component that uses the electron tunneling phenomenon in a superconductive state may open the door to a broad new field of electronic componentry. Though still too new to forecast specific applications, scientists at General Electric's Research Laboratory in Schenectady, N. Y., hold great promise for an experimental cryogenic thin film device similar in effect to the tunnel diode.

Developed by GE's Ivar Giaever, the new device consists of two metal films separated by a very thin insulating layer. With the films maintained at temperatures in their superconductive region (about 1 deg K), Giaever has found that when he applies a voltage across the two films, the device exhibits an S-curve—indicating a negative resistance region—instead of showing a straight line relationship of current increasing with voltage. The S-curve is similar to the tunnel diode characteristic.

• **Simple, cheap, small**—Application of this tunneling effect has up to now been relatively expensive because the tunnel diodes require careful preparation of semiconductor materials. The GE devices apparently would be rather simple and inexpensive to fabricate—and would be much smaller.

For the experimental models made in the GE laboratory, for instance, a narrow strip of metal film (say, aluminum) was evaporated onto a glass slide. Aluminum oxidizes readily when exposed to air, and a thin (one 10-millionth of an inch) oxide coating was thus allowed to form. Then a second metal strip (in one case, lead) was evaporated across the existing layers.

When a potential is applied between these two metallic films, a current flows (or actually, electron waves

Bourns Trimpot® Instead of a Fixed Resistor?

Yes, these units meet the same Mil-Specs that fixed resistors meet and give you the added advantage of adjustability! Because of their design and construction, Trimpot potentiometers are virtually unaffected by the most severe shock and environmental conditions—a fact proven repeatedly in major missile and space programs.

Trimpot units offer several kinds of savings. They minimize the need to maintain stocks of close-tolerance resistors—you can adjust to compensate for the variances of fixed components. Production labor costs are cut, too, for Trimpot units eliminate trial-and-error matching of fixed units to the system. Savings also carry over to maintenance because the technician can adjust equipment quickly in the field—no time and dollars spent to replace components.

Before you specify fixed units, investigate all the advantages offered by Trimpot potentiometers. Over 20 basic models (wirewound and carbon)—in four terminal types and three mounting styles—are available on short notice from stocking distributors or factory. Get the facts...write for the new Trimpot brochure and list of distributors.

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Engineering notes from the **SM/I REPORTER**

BY STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. 15

Type IL2000 Alpha-Numeric Display Module

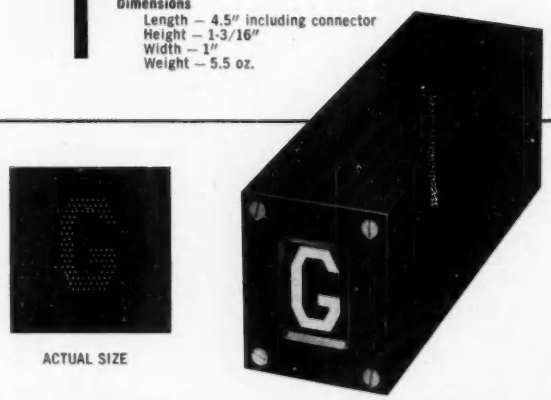
Developed as a company-sponsored project, and the result of many years of visual readout system experience, this small, lightweight device can present from one to 64 individual characters within a maximum change time of 50 milliseconds. Its basic function is converting digital computer outputs into visual display. The alpha-numeric display module is designed to incorporate versatility, clarity, speed, wide-angle viewing, and reliability. A mechanical locking device holds a character display until an erase input is received. Thus it is able to present information continually without any drain on the command input circuit. A memory circuit can be provided so that the module may be interrogated for the character being displayed. The module is internally lighted and each character can be read with clarity from a distance of 30 feet with an included viewing angle of 90°. In addition to 36 alpha-numeric characters, 28 additional character formats may be selected by the customer.

Technical Information

Character Size
Height — 1/2″
Width — 5/16″
Maximum number of characters displayed
6 bit binary input — 64
4 bit binary input — 16

Nominal Operating Data
Voltage — 28 V.D.C.
Power Requirement — .6 watt seconds per bit
Reset Power — .6 watt seconds
Steady State Power — 0 watts
Life Estimated — 5 x 10^5 random indications
Lamp Voltage — 28 volts

Dimensions
Length — 4.5″ including connector
Height — 1-3/16″
Width — 1″
Weight — 5.5 oz.



ACTUAL SIZE

For more information and complete operating specifications, write or wire SM/I today. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

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200 N. Aviation Boulevard
El Segundo, California

WHAT'S NEW

tunnel) through the insulating film. In the temperature range near absolute zero, when both metals become superconductive, the current-voltage relationship exhibits the negative resistance phenomenon described above.

The apparent ease of fabricating these devices means that thousands of such elements could be made at a time. Mass production techniques could be devised, say GE experts, to evaporate the films and allow the oxidation layer to form. Thus it has the makings of a cheap bistable element that could be used as a switch, diode, triode, resistor, or capacitor.

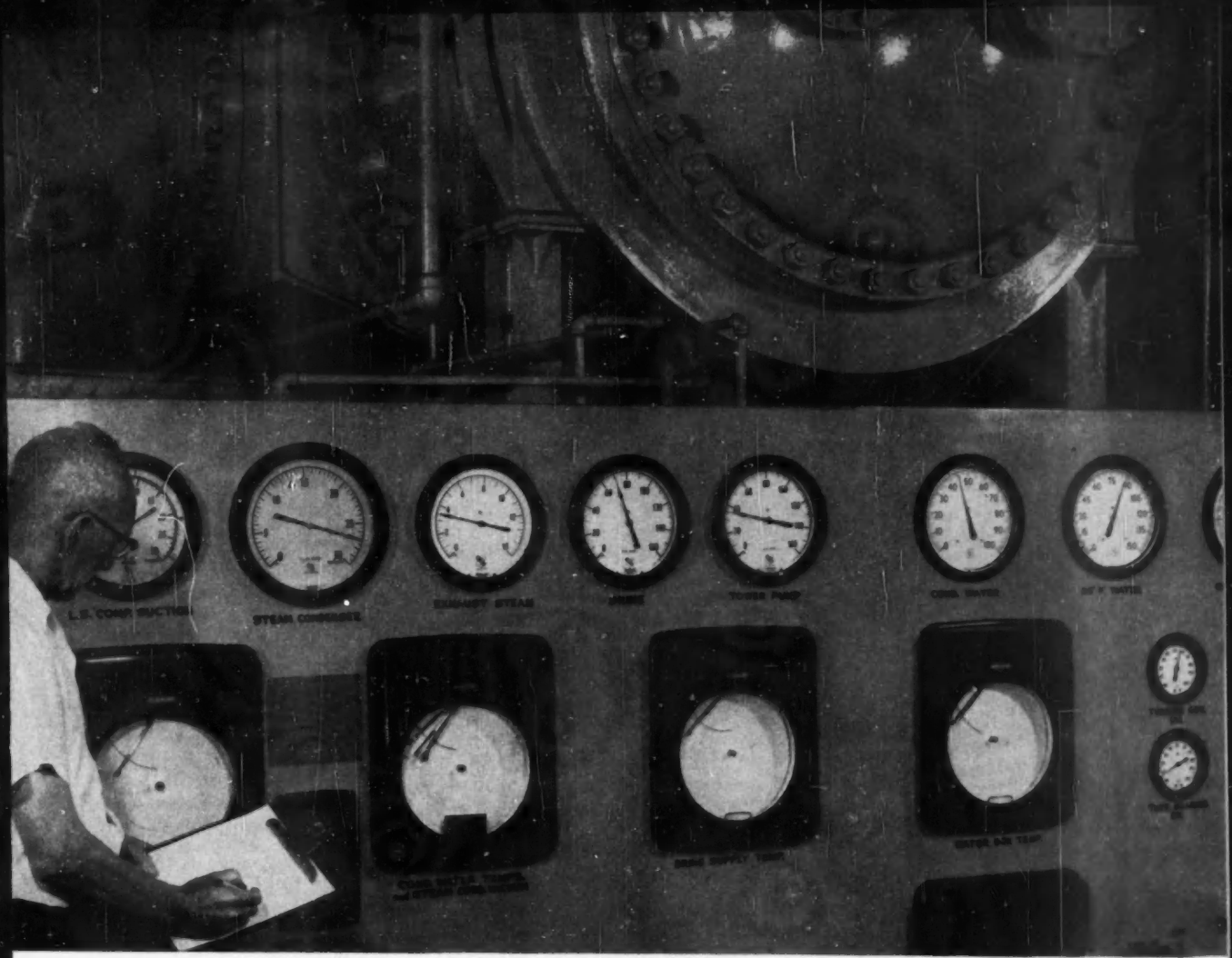
To make a triode, for instance, the effect of magnetic fields on superconductive materials would be employed; magnetic fields return a superconductive metal to its normal state. Giaever has found that at 0.2 mv operating potential, the current through an aluminum-oxide-lead sandwich at 1 deg K changes by a factor of 100,000 when the lead changes from superconducting to normal.

• **Suitable for high speeds**—The frequency of operation of the device would be limited mainly by its capacitance. Giaever suggests that the time constant (RC) of these elements would be on the order of 10 millimicrosec. And power consumption is very small: only a few millivolts. Scores of possible applications suggest themselves: practically anywhere a small, low power, cheap bistable element is needed.

The big question mark in the use of superconductive devices is the need for a cooling system to achieve the near absolute zero conditions. Dr. Guy Suits, GE's vice-president and director of research, says that a suitable cooling system for equipment with this new device can now be made to occupy only 1 or 2 cu ft.

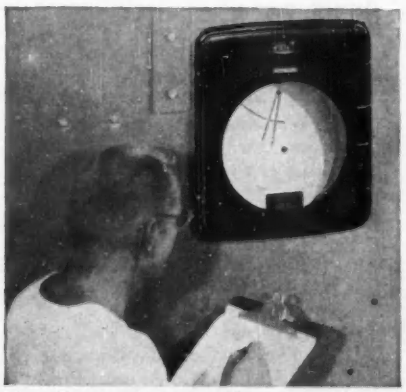
So far Giaever has been able to observe the S-curve only with dissimilar metals. But theory suggests that two films of the same metal could be used, and he expects to be able to prove the effect experimentally.

▶ **Arthur D. Little, Inc.**, Cambridge, Mass., research fim, is also working with this phenomenon. In fact Giaever and the ADL scientists, Dr. James Nicol, Dr. Sidney Shapiro, and Paul H. Smith, published initial reports of their discovery in the same issue of *Physical Review Letters*. Giaever had previously reported his work up to the point of maintaining only one of the film superconductive. ADL has applied for patents on its device (which it calls a tunneltron).



FOXBORO DYNALOG ELECTRONIC CONTROLLERS in Utilities Division, at Kodak Park, Rochester, N. Y. control distribution of refrigerated water throughout Kodak Park Works.

motor load – conductivity – pH – capacitance... Eastman Kodak uses Foxboro Electronic Dynalogs for dependable measurement and control



THIS FOXBORO DYNALOG CONTROLLER is used with a 1/10-inch Foxboro Magnetic Flow Meter to control flow of an additive to Kodak's paper machines at 0.1 gpm.

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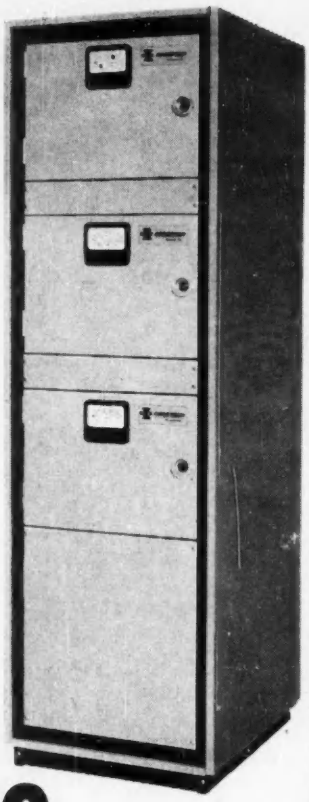
CIRCLE 35 ON READER SERVICE CARD



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3-phase model G6266 WJ-1 (shown) is rated 450 amps at 230, 460, or 600 volts.

Other single and 3-phase models rated from 40 amps to 1800 amps.

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New Controls Spark Renaissance in Italian Machine Tools

MILAN—Italy's machine tool industry is enjoying one of its biggest booms in history. 1960 production was 40 percent ahead of the 35,000 metric tons of machine tools produced in 1959, which was considered a good year by most builders. And 1961 is likely to be even better. At Italy's second international machine tool exhibition (held here in November) builders exuded confidence, aggressiveness, and pride in their new designs—in sharp contrast to the pessimism about the future of Italian machine tools that shrouded these same builders at the first Milan show in 1958. Over 42,000 visitors attended the show and bought over $10 million worth of tools.

One factor contributing to this healthy growth is the unexpected turnabout of Italian labor's attitude toward automatic tools. In 1958 builders faced militant opposition from labor. In 1961 Italy has a labor shortage in a number of areas, particularly in northern areas. The situation is forcing some companies to expand to the populous southern and central part of the "boot."

And the replacement market is growing, too. "If Italian companies replace just 10 percent of their current investment in metalworking and metalforming tools, the Italian machine tool industry would have to double its present capacity," a spokesman for the Italian Association of Machine Tool Manufacturers said. Domestic builders have 70 percent of the Italian market, with German builders leading the list of exporters.

• **Control stars**—Probably the most obvious trend at the show was the introduction of new control systems: programmed control—particularly by punched tape; on-machine gaging, and static controls were among the highlights. The emphasis: flexibility, higher speeds, and more automatic cycles.

Numerical control is a good example of how the Italian machine tool industry is moving. At the 1958 show only one builder—Maxnovo Meccanica di Precisione S.p.A.—displayed numerical control. This year competition was growing:

▶ Item: Olivetti of Milan offered a cam milling machine with a punched tape electronic control. Originally designed for and used in Olivetti's own business machine production facilities, the system is analog and requires a computer to prepare the tape. The machine cuts cams up to a radius of 300 mm (about 11¾ in.) with an accuracy of plus or minus 0.02 mm.

▶ Item: San Rocco of Monza exhibited an electronic positioning system for a boring machine. X and Y-coordinate input data are inserted manually through dials, but the company will soon announce a punched tape control for its boring machine.

▶ Item: Caser of Pavia displayed a punched tape control that directs the positioning table of a turret drill press.

And Maxnova, the pioneer, is still actively marketing its "Telephotomation" punched card control for a lathe.

On-machine gaging was the main feature of a number of designs. For example, Apparecchi Elettronici Marposs displayed its established single and double contact measuring heads with the "finger lock" checking device (CtE, Jan. '59, p. 40). Riv of Turin has licensed the Moore Products Co.'s line of air comparators, multiple gaging, and sorting equipment—manufacturing the machine gaging equipment in Italy.

• **Static controls surprise**—One of the big surprises of the show was the inroad that static control has made on a market traditionally dominated by relays. Besides the line of Westinghouse static control equipment manufactured under license by Ercole Marelli of Milan, seven other suppliers exhibited static control. They were Pellizzari of Milan, Philips Italiana, Richardson Allen Italiana, Brown Boveri, CGE, Cea-Perego, and Riv.

Italian machine tool builders used static controls on a broad range of equipment: grinders, piano-milling machines, boring mills, and lathes.

While the Italian machine tool industry is booming, it is also undergoing an inconspicuous change. Small firms are quietly disappearing or being absorbed by companies on the move. Almost 20 small builders vanished in the past two years. The trend to bigness throughout Italy's industrial complex is manifesting itself in bigger research budgets and growing capital expenditure plans.

—Gene DiRaimondo
McGraw-Hill World News

Inland d-c torque motors

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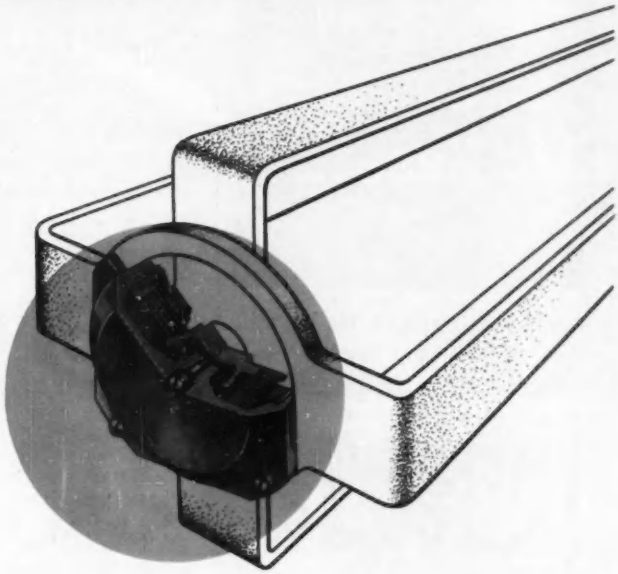
Inland offers a complete line of compact d-c torquers for airborne, shipboard or ground service stabilization and tracking systems. Increased system accuracy has been achieved by mounting the torquers directly on the driven member. This completely eliminates gear backlash and other problems normally associated with gear trains, reduces substantially over-all friction error, and improves the over-all constant of the system. In addition, Inland's d-c torquers combine the compact pancake shape with very high peak torque, low input power, and high angular resolution.

Exclusive commutator and brush rigging design

Inland has achieved this compact pancake shape while maintaining the low-power input to high-torque output ratio of a d-c torquer.



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Peak torque, oz. in.	35	35	35
Volts at peak torque, stalled at 25°C	26.0	20.6	33.5
Amps at peak torque	1.6	2.0	1.3
Total friction, oz. in.	0.8	0.8	0.8
Rotor Inertia, oz. in. sec^2	.007	.007	.007
Weight, oz.	9	9	9
Dimensions (inches):			
O.D.	2.81	2.81	2.81
I.D.	1.00	1.00	1.00
Thickness	.63	.63	.63

For complete data on these or other Inland d-c pancake torquers, address Dept. 5-1, Inland Motor Corporation of Virginia, Northampton, Massachusetts.

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Seeds for Business Outlook Optimism Seen in Spending, Buying Surveys

McGraw-Hill study predicts smaller drop in capital investment than some thought. Machinery orders will be off but will turn up later this year.

U. S. industry's plans for 1961 capital spending show a 3-percent drop from last year's expenditures, as reported by McGraw-Hill Publishing Co.'s annual fall survey of business' spending plans. But the drop seen in the McGraw-Hill survey is relatively small compared to that forecast by other economists. The McGraw-Hill study says total capital investment by U. S. firms this year should reach $35.1 billion; manufacturing companies cooperating in the survey indicate that they will spend $14.3 billion.

Investment in new plants and equipment—considered a key measure of prosperity in the national economy and the prime guide to instrument and control prospects—will be less this year than last. But as indicated by the survey of business' plans, the slump is not expected to continue into 1962. Preliminary plans (and at this early date they tend to be lower than the final figures but this year are especially tentative because of uncertainty over the general economy) show U. S. spending for '62 very close to last year.

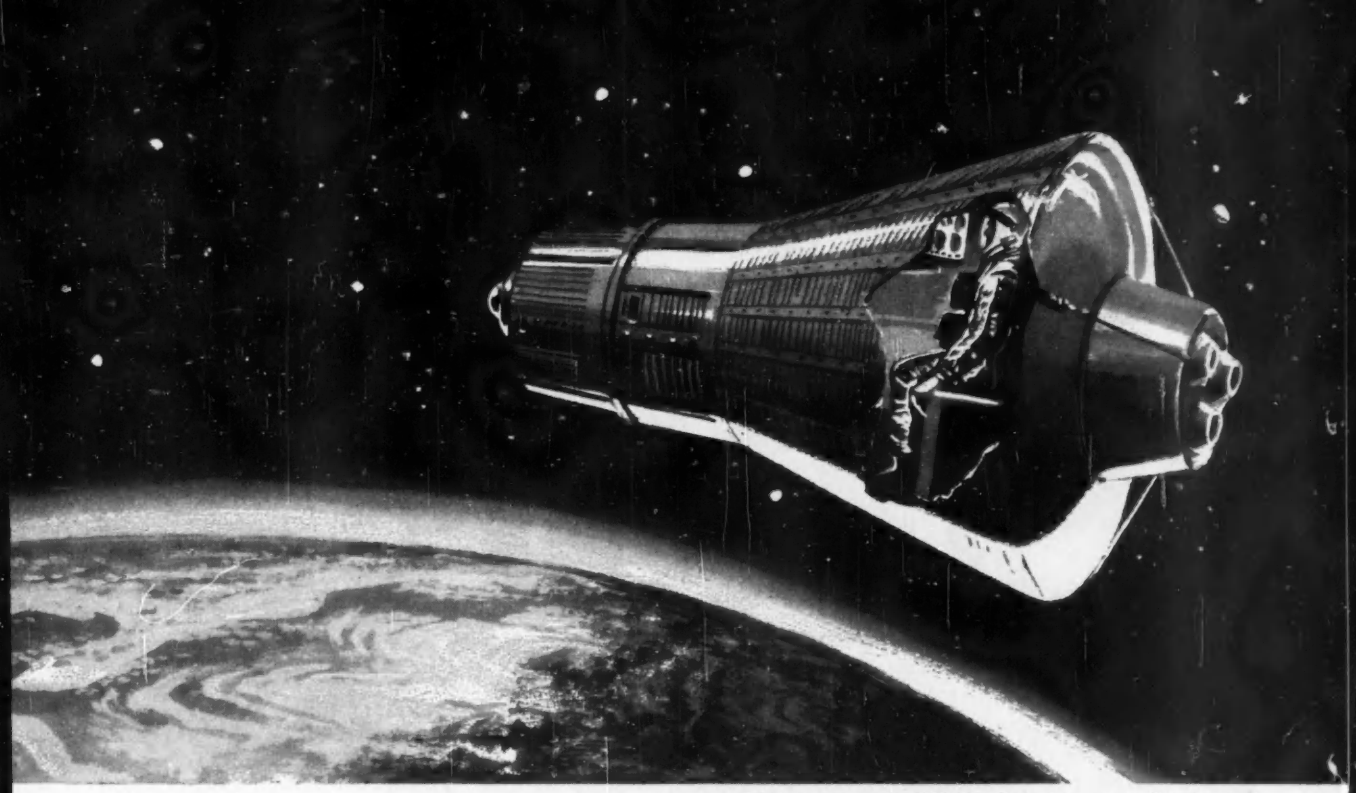
• **Stretched out**—But 1960's final total of capital investment will be significantly lower than originally expected, because many firms have delayed expenditures into this year. This carryover contributes to the $35.1 billion investment total for the year.

The table gives a compilation of the results of the spending survey. It should be noted that these figures are not a forecast; they represent what business plans to spend (as of October 1960). Companies participating in the survey are usually the larger companies in their industry, and this may affect the results. However, more medium sized and smaller companies were surveyed this year than ever before. Also note that the figures in the table do not add to give the total for all business. Segments of the econ-

BUSINESS CAPITAL SPENDING PLANS

INDUSTRY	1959 Actual*	(Billions of Dollars) 1960 Estimated	1961 Planned	1962 Planned	1960–1961 Percent Change
Iron & Steel	$1.04	$1.52	$1.37	$1.18	−10
Nonferrous Metals	.31	.34	.34	.32	0
Machinery	.91	1.15	1.11	1.11	− 3
Electrical Machinery	.52	.62	.68	.63	+10
Autos, Trucks, & Parts	.64	.89	.95	1.02	+ 7
Transportation Equipment (aircraft, ships, RR eqpt.)	.39	.41	.37	.35	−10
Other Metalworking	.88	.97	.85	.87	−12
Chemicals	1.24	1.61	1.64	1.59	+ 2
Paper & Pulp	.63	.75	.69	.53	− 8
Rubber	.19	.24	.23	.20	− 4
Stone, Clay, & Glass	.53	.63	.56	.55	−11
Petroleum & Coal Products	2.49	2.45	2.52	2.50	+ 3
Food & Beverages	.82	.94	.99	.97	+ 5
Textiles	.41	.53	.42	.40	−21
Miscellaneous Manufacturing	1.07	1.28	1.21	1.13	− 5
ALL MANUFACTURING	12.07	14.33	13.93	13.35	− 3
Electric & Gas Utilities	5.67	5.89	6.14	6.01	+ 4
ALL BUSINESS	32.55	36.06	35.07	33.80	− 3

* *U. S. Department of Commerce, Securities and Exchange Commission, McGraw-Hill Department of Economics.*



Orbiting spacecraft of NASA's Project Mercury will be tracked by a global arrangement of 18 communications stations.

Keeping track of a man in orbit

One day this year, the first U.S. astronaut may be rocketed into a globe-circling orbit, some 120 miles in space. Although he will be a mere dot in the heavens, a vast world-wide network of eighteen tracking stations—including two operating from ships at sea—will provide monitoring of every phase of the high-flying astronaut's journey in his orbiting spacecraft.

Linking each of the tracking stations with the project's Space Flight Center at Greenbelt, Maryland, and Mercury Control Center at Cape Canaveral, Florida, will be an array of Teletype equipment —Model 28 page printers, automatic send-receive sets and punched tape units. These Teletype communications devices will record and relay flight data collected by tracking and telemetering equipment from the spacecraft's instruments to the Flight Center, where an elaborate complex of data processing machines will coordinate and interpret flight data and provide directive information for the world-wide network of tracking stations.

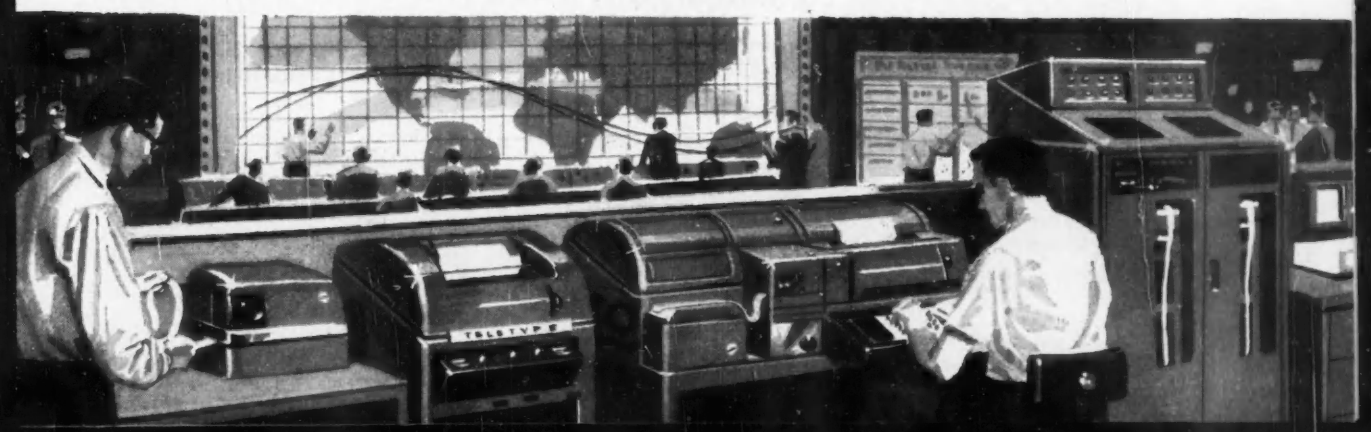
Teletype Corporation is indeed proud to be a part of the Western Electric industrial team selected by the National Aeronautics and Space Administration (NASA) to build the vast communications network so vital to Project Mercury.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

Dept. 21-A, 5555 Touhy Ave., Skokie, Ill.

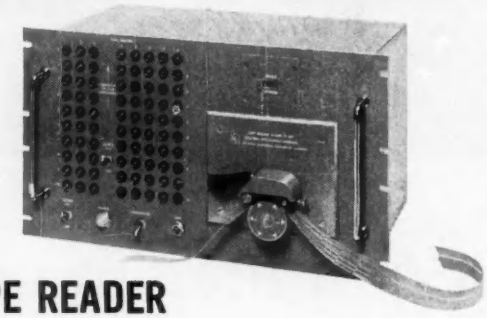
Teletype page printer, tape punch and reader units will be used throughout Project Mercury's global communications network to gather and relay flight data.

CIRCLE 39 ON READER SERVICE CARD



HOLE HEARTED

IS THE JOB DONE BY EECO'S LONG-LIVED TP-401 PUNCHED-TAPE READER



Looking for improved tape-ability? For sequencing automatic testing in ground support, or for the control of simulation devices, this ruggedized punched tape reader makes better, more reliable contact than any other reader because of unique springloaded pins.

Reads 80 bits per frame at 6 frames per second. Searches at 12 ips. Includes neon-lamp verifier panel for quick checking of new tapes. Uses 1" paper or tough mylar tape with standard eight-level 0.1" punching. Manual or remote stepping, 4-digit frame counter with reset, other desirable features.

Costs only $1,620 f.o.b. Santa Ana. (Or $1,490 for model TP-402 without verifier.) Send for Data File TP-401.

EECO also makes these other punched tape readers for special applications:

Model TP-813 13-channel programmer for airborne use. $990.

Model TP-201A 80-bit bi-directional programmer. $1,160.

Model TP-860 8-channel time base programmer. $875.

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TWX: SANTA ANA CAL 5263

Several important career opportunities are now open in EECO's engineering department. Call or write Merl Perkins.

EE 0-18

See EECO on Display—Booth 2—Winter Convention of Military Electronics, Biltmore Hotel, Los Angeles, Feb. 1-3

omy outside the direct interest of the control field have been omitted from the tabulation but added into the total.

The second largest decline in spending for this year is in the other metalworking industries group, which includes instruments along with fabricated metals. Figures for other control goods are hidden in the totals for the machinery and electrical machinery industries.

• **Sales on the upgrade**—Manufacturers, on the average, expect this year to be a better one than 1960. This was reported in the coincident study of business' sales expectations. Manufacturing companies forecast a 3-percent gain, and an increase as large as any other industry group's is seen by the other metalworking firms: 5 percent. These figures refer to physical volume, not dollar sales.

From another McGraw-Hill research report, a quarterly machinery new orders forecast, some good news can be gleaned. The downturn in machinery orders expected by most experts for the first part of this year is foreseen also by this study. But there should be an upturn to last year's levels later in the year.

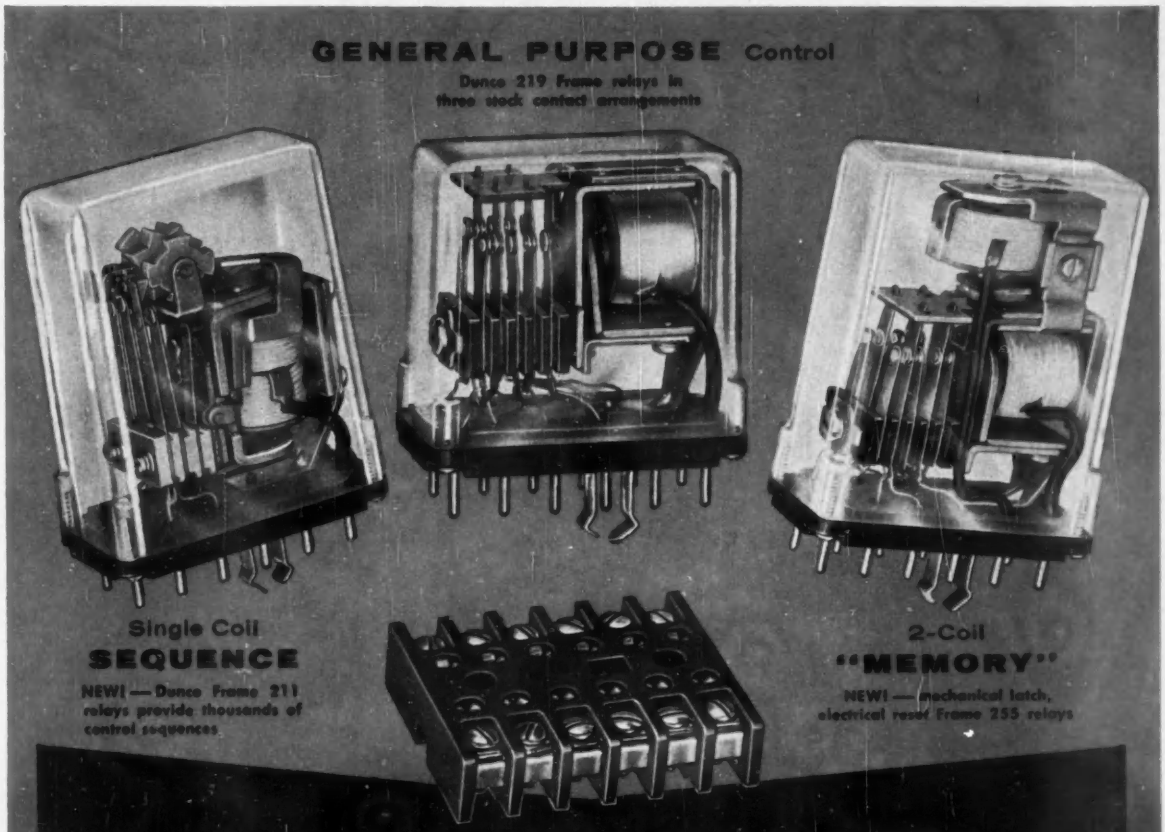
Capital goods producers cooperating in the forecast saw the dollar volume of their new orders falling through the second quarter of this year. But they expected an upturn in the second quarter so that by the third three-month period, new orders should be flowing in at the same levels as in that part of 1960.

The forecast indicated a dip of 11 percent in bookings of new orders between the third quarter of last year and the first quarter of this. But between the first two quarters of this year, incoming new business was expected by the companies reporting to be due to rebound 6 percent with an equal rise between the second and third quarters. So a disappointing start should be followed by steadily improving prospects.

EDP Corners Business Exposition

LOS ANGELES—Electronic data processing equipment sales will double within five years. This was the buoyant forecast of EDP makers participating in the recent Business Equipment Exposition held in the Memorial Sports Arena

(Continued on page 150)


GENERAL PURPOSE Control
Dunco 219 Frame relays in three stock contact arrangements
Single Coil
SEQUENCE
NEW! — Dunco Frame 211 relays provide thousands of control sequences
2-Coil
"MEMORY"
NEW! — mechanical latch, electrical reset Frame 255 relays

A COMPLETE RELAY LINE FOR

Simplified, Economical Industrial Control

This dependable Dunco relay "family" paves the way to practically any needed industrial control sequence, "memory" or operational circuitry feature.

Smaller, moderately priced and requiring less operating power, Dunco 219 Frame relays have revolutionized many control panels previously "over relayed" with larger, more costly contactor type units than needed.

Now, in matching types, Dunco offers 255 mechanical latch, electrical reset and Frame 211 sequence relays.

All feature 12-pin plugs with heavy-duty industrial sockets. Contacts are conservatively rated at 10 amperes. Standard 150 volt electrical spacings are used throughout. All three types are designed for maximum control panel simplification and in minimum size for dependable service over millions of operations.

Write for Data Bulletins on any type to Struthers-Dunn, Inc., Pitman, N. J.

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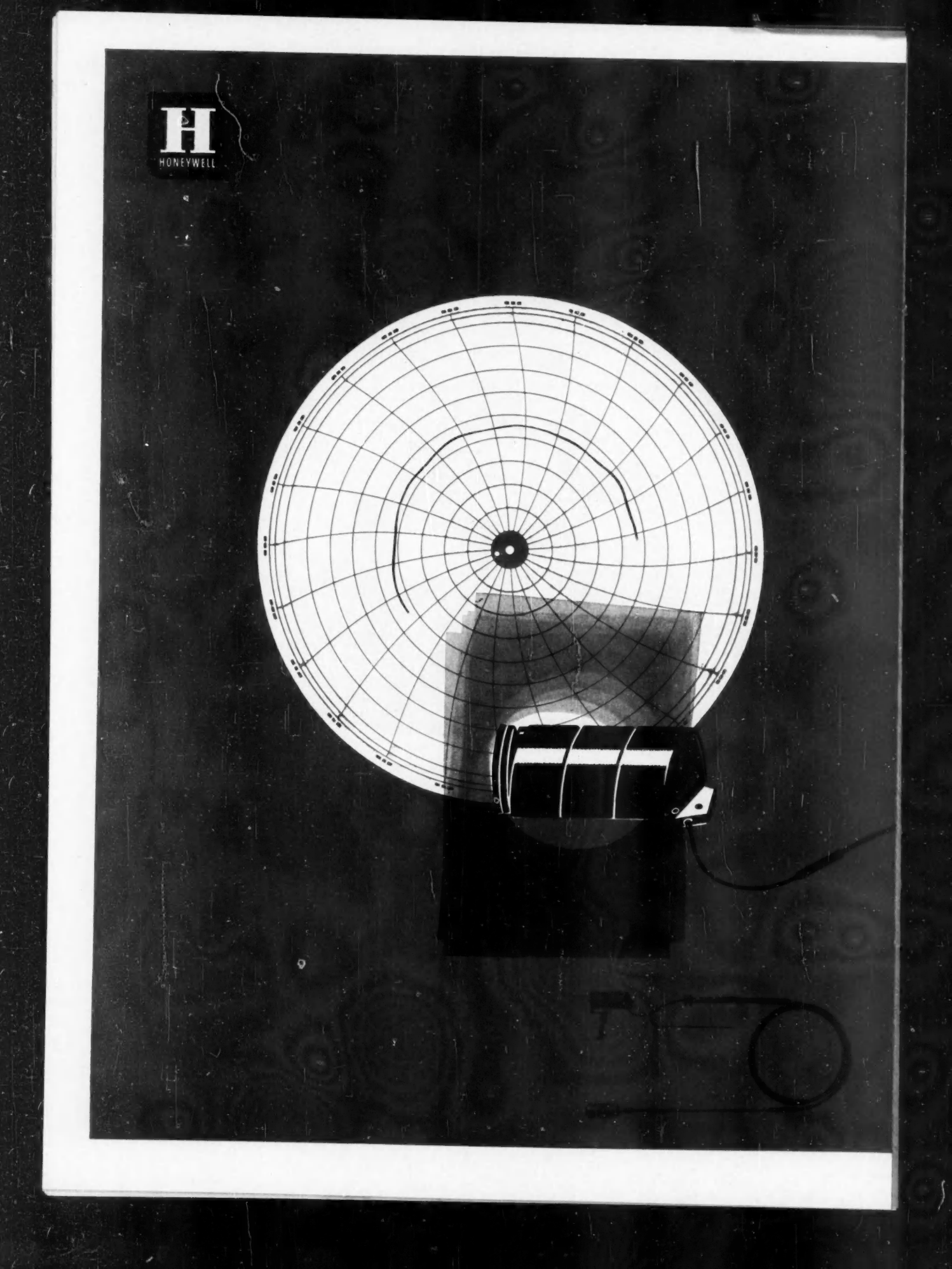
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The New Honeywell Thermal System

withstands extreme vibration and corrosion conditions

Here's a new gas-actuated thermal system that takes the zig-and-zag out of temperature recording under severe vibration conditions.

A complete series of vibration tests has proved the vibration resistance of the new Class III thermal system. In these tests, the Class III system was installed in a standard Honeywell rectangular case recorder, and subjected to forced vibrations in three mutually perpendicular planes. With accelerations up to 0.2G from 0 to 200 cps, maximum pen oscillation was limited to 1.5%. For more than 75% of the range, *pen oscillation was less than 0.5%!* . . . with no resonant effects at 60 cycles.

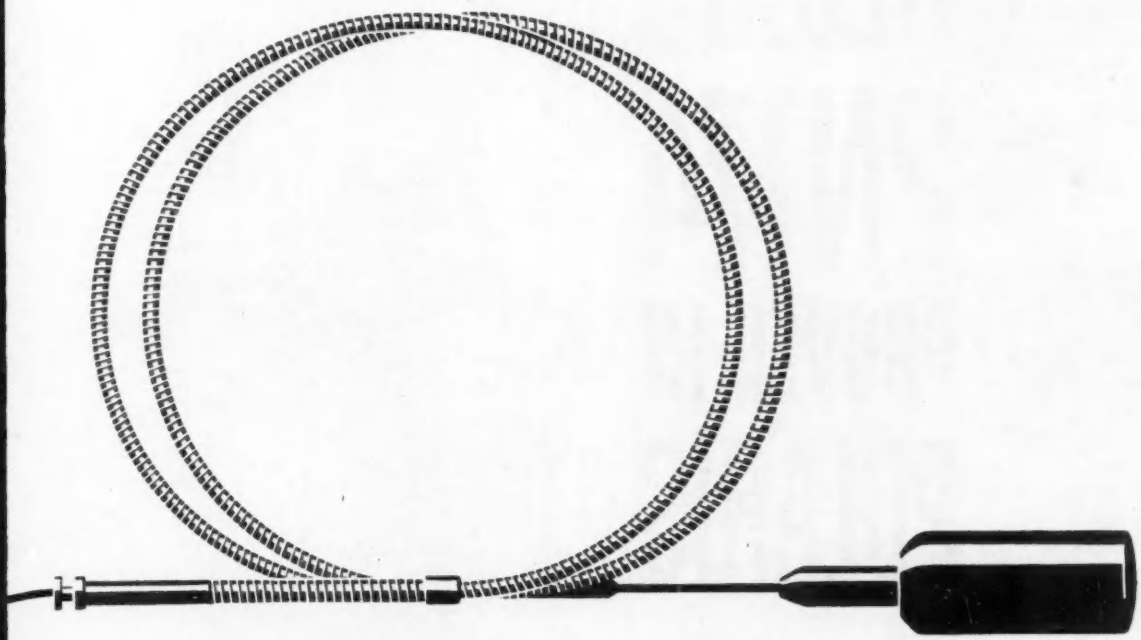
Check these many new design and construction features: high-energy helix for increased sensitivity and lower dead spot; built-in overrange or underrange protection; stainless steel bulbs to withstand corrosive atmospheres; low carbon 316 stainless steel linkages with low-friction, ball-joint construction; coarse and fine zero adjustments for easy settings.

Get the complete story on the new Class III Thermal System by contacting your nearby Honeywell field engineer today. He's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pennsylvania.

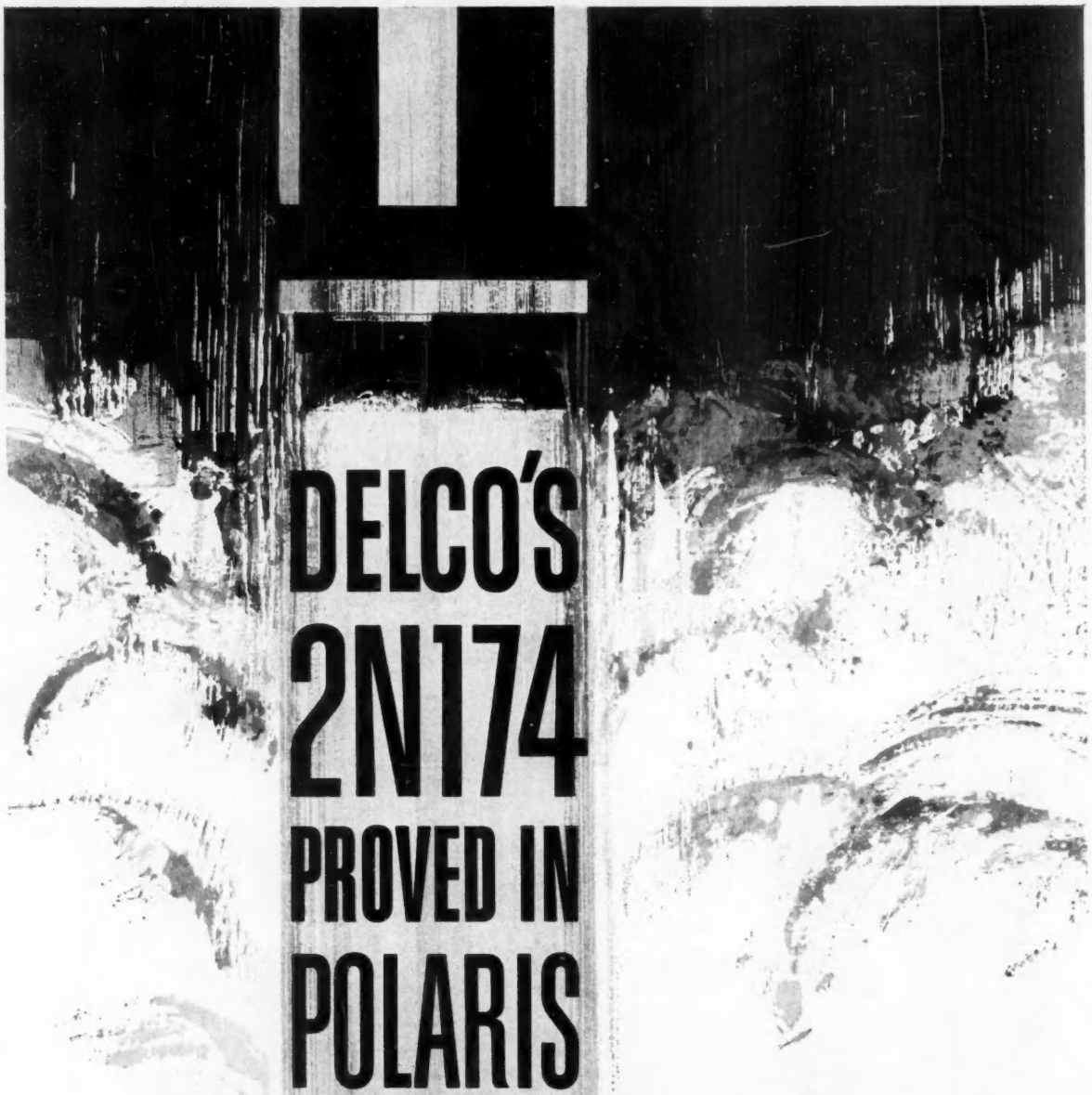
Honeywell

First in Control

SINCE 1885



CIRCLE 43 ON READER SERVICE CARD



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Over the past five years since Delco first designed its 2N174, no transistor has undergone a more intensive testing program both in the laboratory and in use, in applications from mockups for commercial use to missiles for the military. And today, as always, no Delco 2N174 leaves our laboratories without passing at least a dozen electrical tests and as many environmental tests before and after aging.

This 200 per cent testing, combined with five years of refinements in the manufacturing process, enables us to mass produce these highly reliable PNP germanium transistors with consistent uniformity. And we can supply them to you quickly in any quantity at a low price.

For complete information or applications assistance on the Military and Industrial 2N174's or other application-proved Delco transistors, just write or call our nearest sales office.

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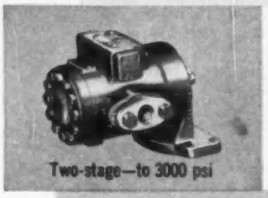

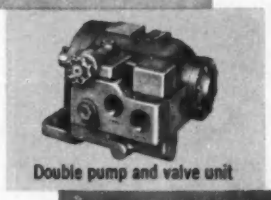

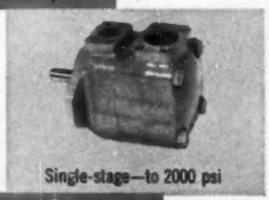

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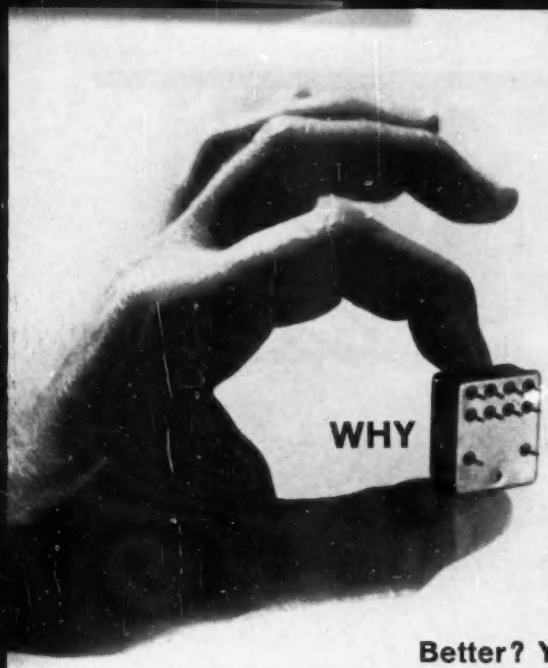


WHY THIS IS A BETTER *LATCHING* RELAY

Better? Yes, in several ways. Bifurcated Contacts, for example, give improved reliability, especially in dry circuits. Contacts will not open during vibrations of 30Gs, 55 to 2500 cps. A special method of sealing cover to base eliminates flux contamination of the contacts. And there are more. Here is Potter & Brumfield's newest member of a distinguished family of micro-miniature relays: the FL Series.

Expressly designed for printed circuit applications, this DPDT, 3 amperes (@ 30V DC) latching relay lies parallel to the mounting surface. Its height, when mounted, is only .485", thus circuit boards may be stacked closer. Mounting can usually be accomplished without studs or brackets, simplifying installation.

The FL will remain firmly latched in either armature position without applied power, a significant advantage where power is limited and long relay "on" times are required. This relay may be operated by:

1. Pulsing each coil alternately (observing coil polarity), or
2. Connecting the coils in series and operating from a reversing (polarized) source.

Write for complete information or call your nearest P&B representative.

FL SERIES SPECIFICATIONS

Shock: 100 Gs for 11 milliseconds. No contact openings.

Vibration: .195", no contact openings. 10 to 55 cps. 30 Gs from 55 to 2500 cps.

Pull-In: 150 milliwatts maximum (standard) at 25° C. 80 milliwatts maximum (special) at 25° C.

Operate Time: 3 milliseconds maximum at nominal voltage at 25° C.

Transfer Time: 0.5 millisecond maximum at nominal voltage at 25° C.

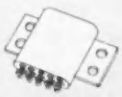
Temperature Range: −65° C to +125° C.

Terminals: Plug-in pins.

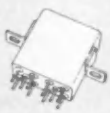
Dimensions: L. 1.100" Max.—W. .925" Max H. .485" Max. Hermetically sealed only.

SC 11 D

SCG 11 DC



SL 11 DB
(Latching)



SLG 11 DA
(Latching)

Other P&B micro-miniature relays include conventional and latching models in crystal cases with a wide range of terminals and mountings. All are made in a near-surgically clean production area under the exacting requirements of our Intensified Control and Reliability program.

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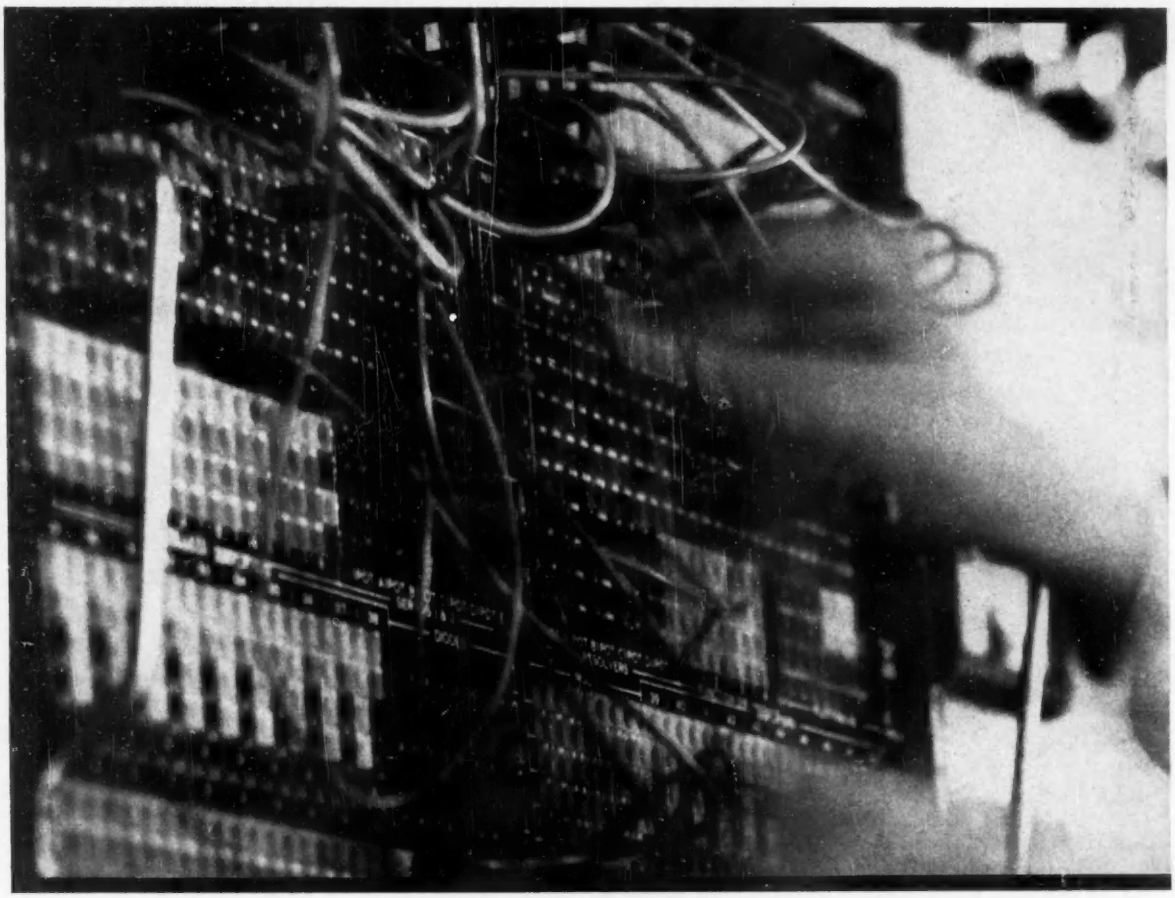
DYSTAC*



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DYSTAC provides unique time-sharing of computer components and high speed reiterations. These features make possible economic and rapid solution of complex problems that have required too many computer components or too long a solution time to be considered practical for either digital or analog techniques. Different combinations of this new development readily solve problems in four broad categories.

- Sequential calculation, as encountered in the distillation problem. Here, successive solutions to algebraic matrices are obtained from cycle to cycle at a repetitive speed of 60 cps until the problem is solved.
- Definite integral calculations. Varying definite integrals are evaluated from one cycle to another and held in memory for the successful solution of optimization problems.
- Rapid evaluation of multiple integrals. This technique can be employed for the solution of partial differential equations.
- Transient problems and difference-differential equations are solved with continuous memory.

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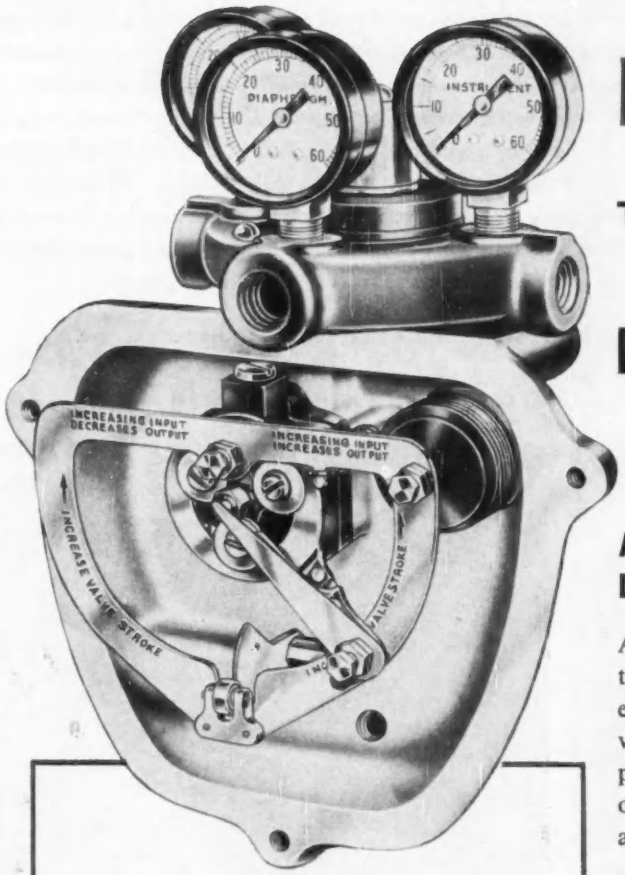

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CHARACTERIZED CAMS . . . offer wide flexibility in valve characteristics.

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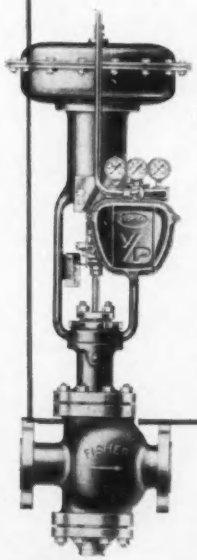

PERFORMANCE DATA

Hysteresis, (Average)	0.0012"
Linearity	as required. Change cams to obtain desired characteristics
Sensitivity	0.14 psi
Resolution Sensitivity	0.002 psi
Repeatability	±0.0003"
Stroking Speed	0.37 in/sec.
Air Consumption	10 scfh
Break Frequency (5% of instrument pressure range)	3.9 cps
Break Frequency (3% of instrument pressure range)	4.6 cps

The above performance data was taken from laboratory tests on a Type 657 diaphragm actuator, Size 40, with 1½" travel. Instrument range 3 to 15 psi.

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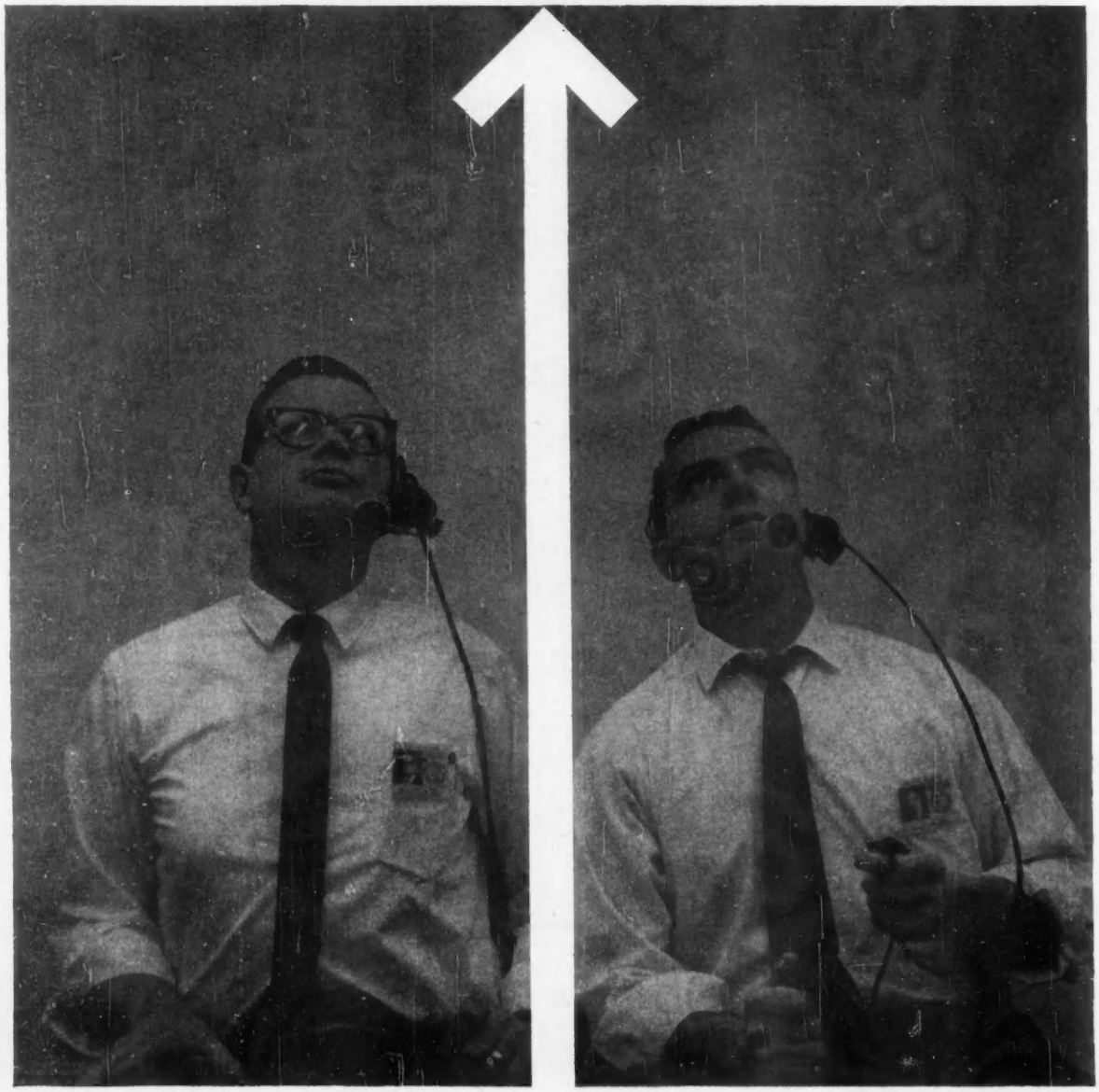

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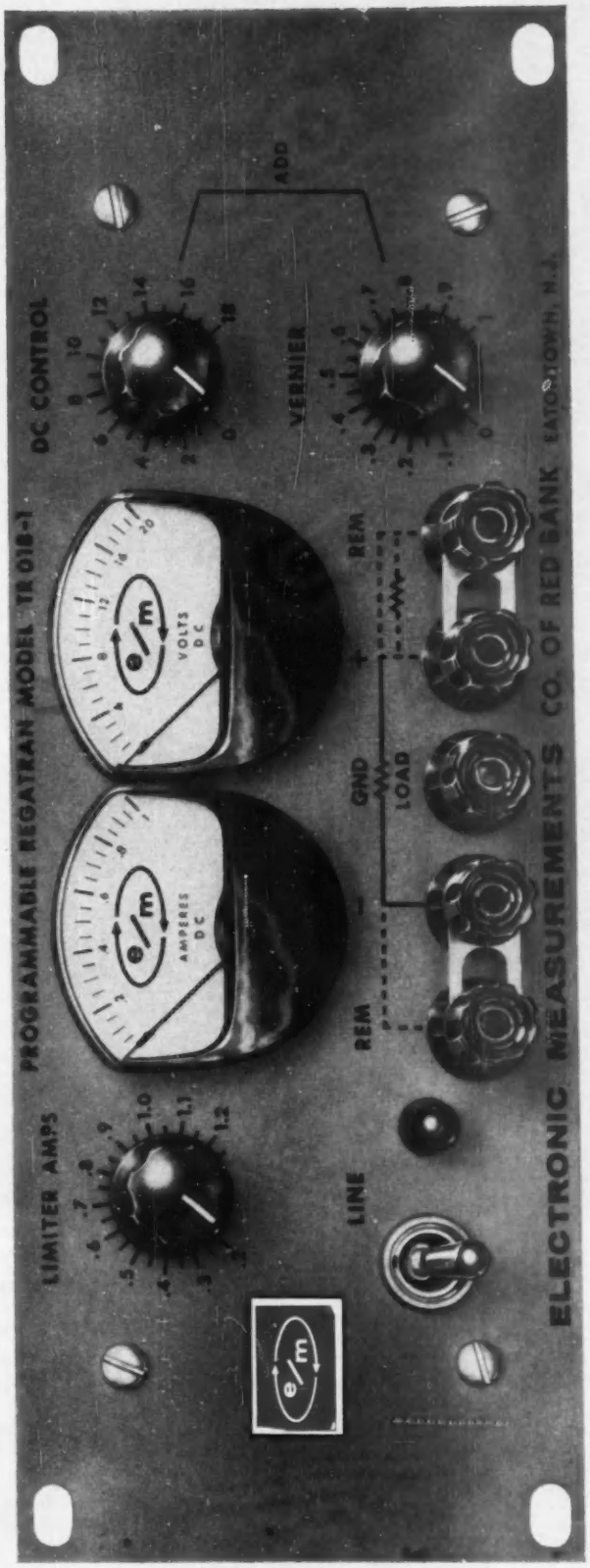
REGULATION, LINE OR LOAD, 0.1% OR 0.01 V

MODEL NUMBER	DC OUTPUT		MAX. RMS RIPPLE
	VOLTS	AMPS	
TR212A	0-100	0-100 MA	250 μv
TR018-1	0-18	0-1 AMP	150 μv
TR036-0.2	0-36	0-200 MA	150 μv

For a closer look, ask your local Electronic Measurements representative for a copy of Specification Sheet 5000 . . . or write direct.



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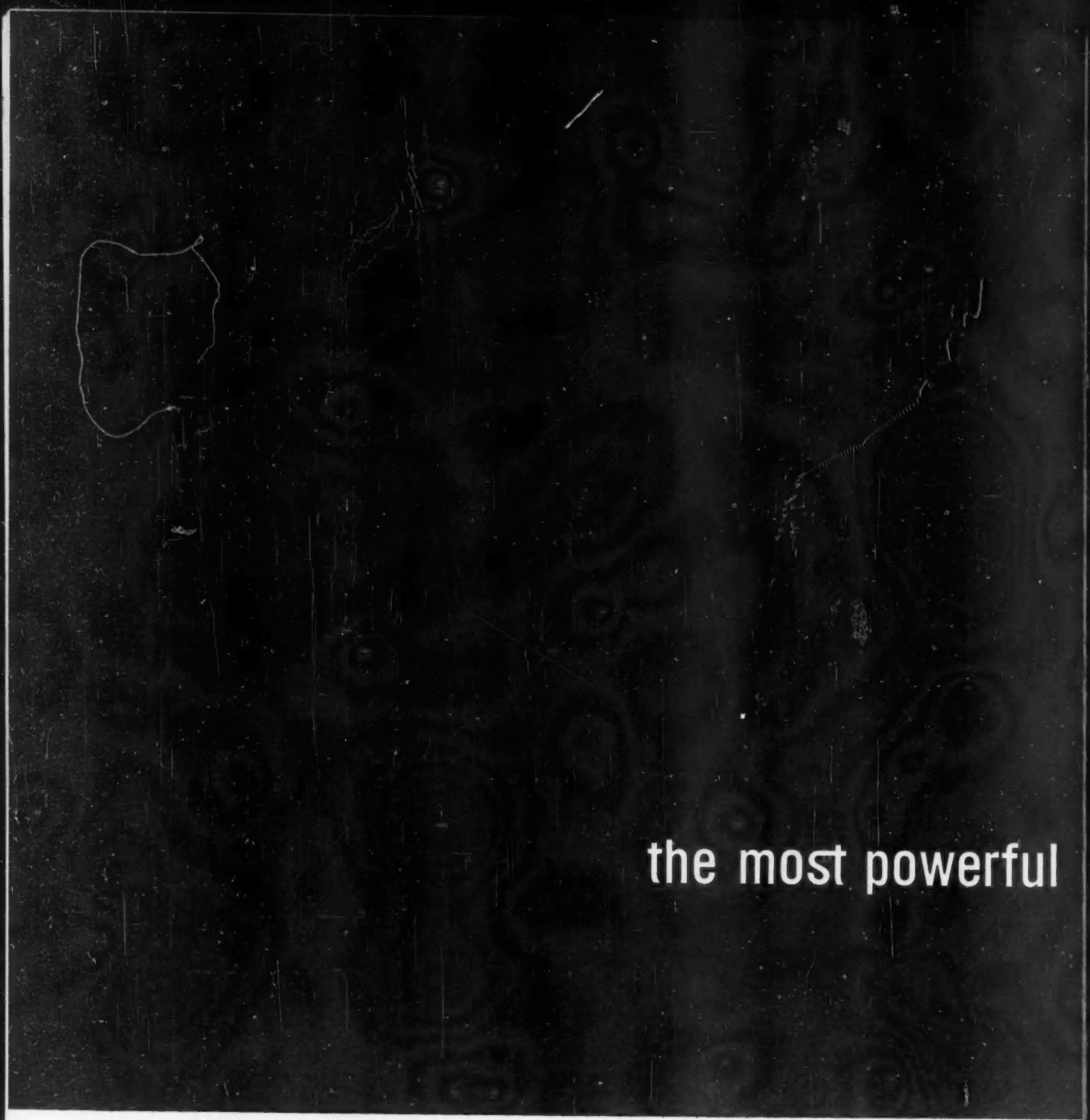

Westinghouse 30-amp silicon "rock-top" power transistors

New 30-amp ratings, the industry's highest! These latest Westinghouse Silicon Power Transistors are especially designed for those applications where you need more transistor power, extra long-life and extra stability under all operating conditions. Your choice of nine devices in this new family—each rated at 30 amps.—for greater flexibility of circuit design in high-power applications. Other Westinghouse high-performance features include: • Exclusive "rocktop" ceramic construction for greater reliability • Voltage ratings to 200 volts • Double-ended case design • Low saturation resistance • 250 watts power dissipation.

CIRCLE 53 ON READER SERVICE CARD

transistors you can buy...

Production quantities of the type 115 family are now available. Westinghouse also offers the 2N1015 and 2N1016 series of Silicon Transistors, ideal as companion drivers. Military and industrial applications include: power supplies/regulators/amplifiers/high-power switching/inverters.

For more information call your nearest Westinghouse representative or semiconductor distributor. Or write: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Pa. SC-1012

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The Litton LN-3 Inertial Navigation System is a system in being. Production orders for this system to be used in the F-104 are, to the best of our knowledge, larger in number than those for any other inertial guidance system. The LN-3, consisting of a two-gyro, four-gimbal platform, computer, adapter, and controls, weighs less than 80 pounds installed. Even smaller systems, designed for orbital and sub-orbital guidance, are in development. These will weigh less than half as much as systems now in production.

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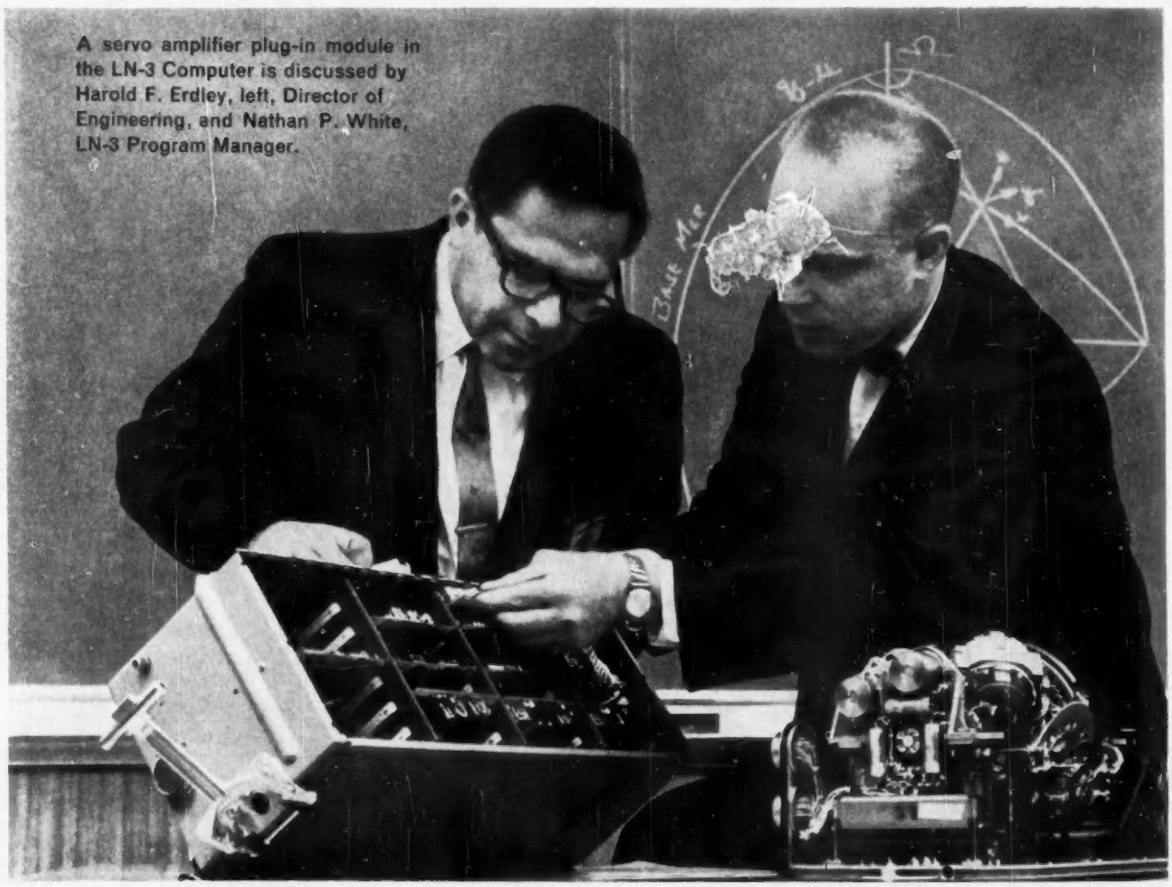
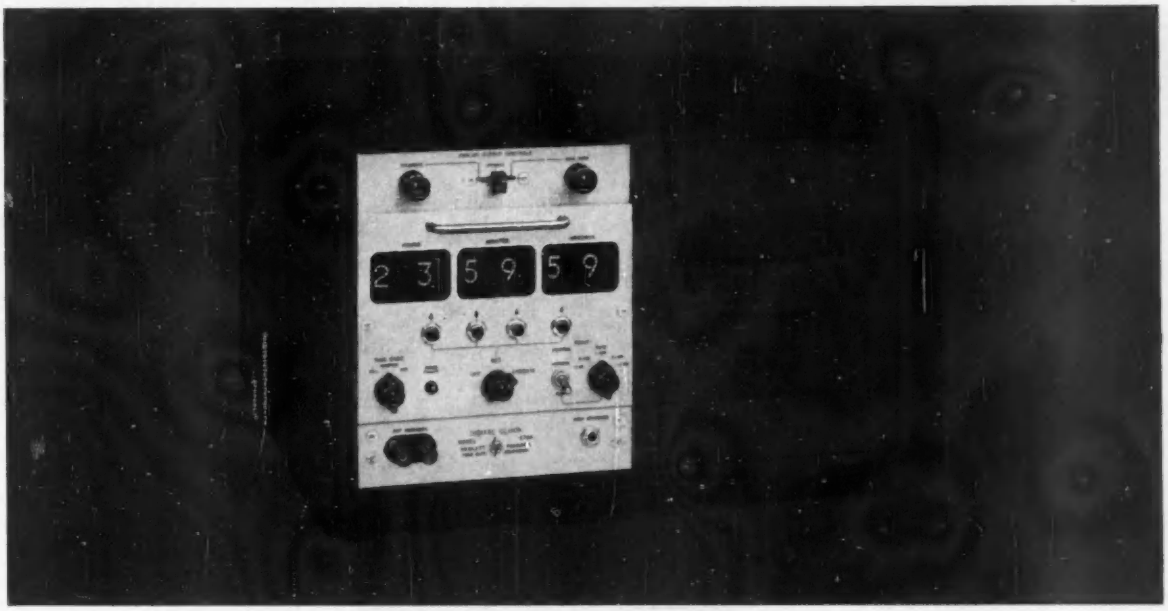
GUIDANCE & CONTROL SYSTEMS DIVISION
Beverly Hills, California



A servo amplifier plug-in module in the LN-3 Computer is discussed by Harold F. Erdley, left, Director of Engineering, and Nathan P. White, LN-3 Program Manager.

NEW CLOCKS FOR hp DIGITAL RECORDERS



add time-of-day to recorded data
control taking of readings
fit in Digital Recorder cabinet
available for field installation

New hp 570A and 571B Digital Clocks mount in the left-hand side of hp 560A and 561B Digital Recorders, respectively. The clocks may be installed in the field, and fit either in cabinet arrangement, as shown, or into a combined Recorder-Clock rack mount arrangement only 10½" high.

Time appears as a 23 hour, 59 minute, 59 second presentation (12-hour clocks are available on special order). Display is by long-life, in-line indicator tubes. All time digits are available for printing.

Two operating modes provide utmost usefulness. In the first mode, hp or Dymec Digital Counters, Digital Voltmeters or other external equipment control print rate; time being printed simultaneously with other data. In the second mode, for tests where less frequent readings are desired, the Digital Clocks control the timing of readings. A front panel control selects reading rates of 1 per second, 6 per minute, 1 per minute, 6 per hour or 1 per hour.

SPECIFICATIONS

Indication: Six in-line long-life digital display tubes. Indication to 23 hrs., 59 min., 59 sec.

Time Base: Ac line, 1 pps from counter, or external 1 pps.

Accuracy: Time base accuracy + 0, — 1 second.

Print Control: Front panel control selects CLOCK or EXTERNAL control mode. PRINT RATE of 1 sec., 6/min., 1/min., 6/hr., 1/hr. also chosen on front panel control.

Output: Six time digits for time recording. Holdoff signals for hp, Dymec counters.

Power Interruption Alarm: Front panel warning light.

Analog Output: 570A retains analog output of 560A.

Prices: hp 570A (fits hp 560A/AR) $1,050.00; hp 571B (fits hp 561B/BR) $950.00.

Data subject to change without notice.
Prices f.o.b. factory.

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EAI Series 5000 features include –

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- ☐ **200 readings per second average**
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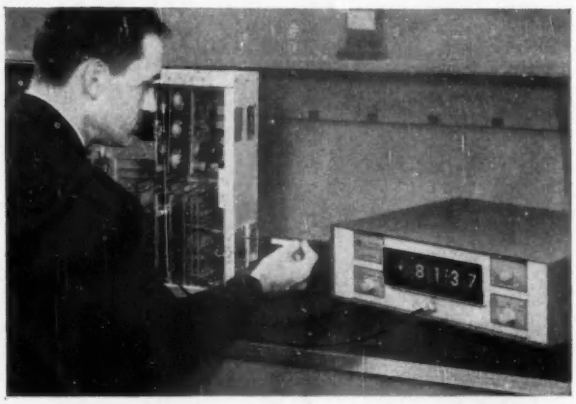
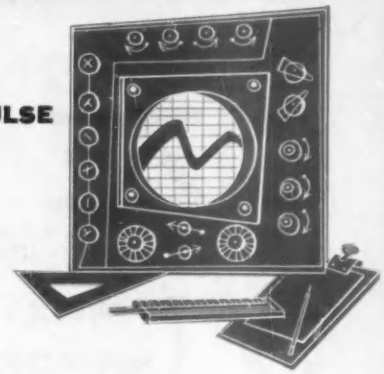


Write for complete details on the new Electronic Associates, Inc. Series 5000 Voltmeters, or call your nearest EAI Engineering Representative.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*



Growing Market in Europe And How to Sell It—Part I

Production of German measurement and control equipment jumped almost 30 percent last year. French control makers reported a 15-percent gain in 1960, are looking forward to a 10-percent increase this year and again in 1962. British instrumentation rose 10 percent last year, is expected to grow another 20 percent in 1961. All this is part of the mass production revolution that has hit Europe and turned it into one of the lushest markets in the world for measurement and control equipment. To satisfy a prosperous dynamic economy, European manufacturers are building sparkling new plants and updating old ones; both types are being equipped with the latest control systems and devices.

As a sample of what is ahead, the chemical industry of Europe is expected to double its capacity over the next 10 years. European steel producers now plan to add 110 million tons of capacity in the next five years.

"In many respects", commented one veteran international marketer, "Europe's like an old fashioned U.S. gold rush or oil strike. Deliveries of standard equipment run from 10 to 18 months, and interest is almost unbelievable. At Interkama, a German instrument and control show, 110,000 people turned up. At Milan's machine tool show, over 42,000 attended and bought $10 million worth of tools at the show."

For a detailed look at this amazing selling phenomenon, CtE asked its European newsmen for a last minute report. From Europe came back an almost unanimous reply: "Control business is booming."

From Bonn, Germany, McGraw-Hill Newsman James Morrison cabled this report.

Full order books and delivery delays have forced West German manufacturers of control equipment to soft pedal research and development and concentrate their efforts on expanding production, repackaging their products, and transistorizing wherever feasible. In 1960 German production of measurement and control equipment topped $300 million—up from the $230 million recorded in 1959.

As a sign of prosperity, Germany is suffering the worst labor scarcity in its history. The government imported over 96,000 unskilled foreign workers in 1960 to help ease the shortage. Skilled workers are at a premium, a situation that is slowing the increase of production in those industries (such as the control field) that require a large infusion of skilled labor.

U. S. firms have been capitalizing on this. The Germans think that U. S. successes in Germany can be traced to America's ability to deliver equipment almost off the shelf. In addition, subsidiaries of American firms, say plant engineers, are taking advantage of about a two-year lead in the state of the art: U. S. designs are about two years ahead of German ones.

One plant engineer told CtE that U. S. companies have introduced a new selling era into Europe by sending engineers—not salesmen—into the field to sell service as well as product.

In Germany today the equipment used for measurement and control purposes is a mixture of electronic, electric, pneumatic, hydraulic, and optical control components. About 33 percent of production goes for hydraulic controls; 28 percent for electronic or electric; 21 percent, pneumatic; and the rest, combinations. A representative of VDI, the association of German engineers, predicts that this proportion will shift sharply over the next few years. He says that electronic and electric control will grab up to 40 percent of production, while hydraulic controls would decline to 25 percent and pneumatics would drop to 14 percent of production.

Electronic control and instrumentation are definitely winning increased acceptance in the German machinery, machine tool, and chemical processing industries. But German manufacturers feel that some of their designs are too large and complicated and are still using an excess of mechanical techniques instead of electronic components that would reduce size and simplify the configuration (for an indication of how German designs have started to follow the U. S. lead, see CtE, December, 1960, p. 30). As part of this miniaturizing program German manufacturers are expecting wide usage of transistorized static switching.

A recent survey of German users indicates that price is not the only criteria for purchase. In the study, well over 50 percent of the respondents said they bought control equipment primarily on the basis of reliability. Twenty-eight percent thought accuracy most important. Only five percent rated price the dominant factor.

In England, Derek Barlow, CtE's European editor, noted a different situation. U. S. firms through licensing agreements and subsidiaries have cornered a big share of the British market, estimated from 50 to 70 percent. Barlow had this to say about the situation:

British production of control equipment in 1960 is expected to reach $237 million when the figures are all in, a striking comparison to 1957, for example, when the industry produced products worth only $184 million. Industrial controls account for half this output. Estimates for 1961 are even more optimistic. British manufacturers plan to increase their capacity by 20 percent, and instrument and control production should grow as much.

One area that is planning extensive growth is the petrochemical industry. For example, Imperial Chemical Industries expects to spend $280 million developing a 1,000-acre site at Severnside. First installation: an ethylene oxide and glycol manufacturing facility. And Esso Petroleum is building a 70-mile pipeline to move basic ethylyene to it. British Petroleum will build a $22.4 million refinery in Northern Ireland.

Another area that will be using a lot of instrumenta-

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Extreme uniformity and thermal stability are maintained in these premium synchros in all electrical characteristics—and especially accuracy.

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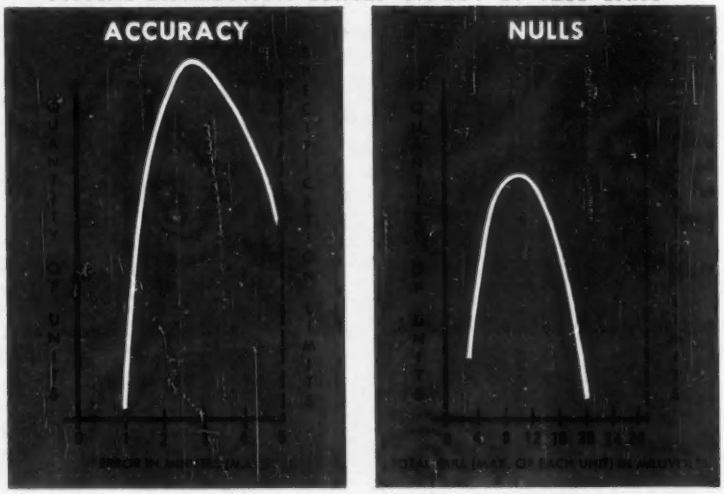

ELECTRICAL CHARACTERISTICS

SYNCHRO FUNCTION	CPPC TYPE	ROTOR AS PRIMARY						STATOR AS PRIMARY						D.C. RESISTANCE		IMPEDANCE				ACCURACY
		Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Rotor (Ohms)	Stator (Ohms)	Zro (Ohms)	Zso (Ohms)	Zrso (Ohms)	Max. Null Voltage (MV)	Max. Error (Min.)
Torque Transmitter	HGC-8-A-010	26	.120	.66	11.8	206	10.0	—	—	—	—	—	—	37	12	46+j210	11+j36.5	81.5+j24	30	5
Control Transformer	HTC-8-A-010	—	—	—	—	—	—	11.8	.039	.092	22.5	393	10.5	365	64	400+j1420	60+j254	590+j176	30	5

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CLIFTON PRECISION PRODUCTS CO., INC.

Clifton Heights, Pennsylvania

ENGINEERS—Join a pioneer in the rotary components field. Write David D. Brown, Director of Personnel.

tion and control is the steel industry. W. T. Marchment, chairman of the British Industrial Measuring and Control Apparatus Manufacturers Association, credits the introduction of new processes for increased use of automatic control. Typical example; the new oxygen-blown Bessemer steel-making process. And, says Marchment, small companies now realize that they can't afford to let automatic controls and instrumentation be the province of big companies. Many small industries are using small multiloop systems for the first time.

This year will see the start of computer control in Britain. Ferranti has sold two applications of its Argus process control computer—one for automatic boiler startup and the other to control a chemical plant. Elliot-Automation has orders for 40 systems; 10 were exported to U. S. customers for on-line control; of the four delivered in the United Kingdom, two have been for on-line control. Elliot expects to sell over 40 more computer process systems this year.

Although most British companies are optimistic about 1961, they are almost delirious over the prospects for 1962. According to leading industrialists, 1962 will see the introduction on a large scale of major automatic control systems that will make extensive use of computers and data reduction systems.

In Paris, McGraw-Hill Newsman Arthur Erikson sounded out executives of the French instrumentation and control industry, heard reports of growth that ranged from "10 percent a year for the next three years" to "a major boom is developing." Erikson cabled:

At the Electrical Industries Trade Association the specialist on instruments and controls pegs future French instrumentation growth at about 10 percent annually for the next two or three years. This is on top of a three-year growth that has carried the industry to 1960 sales of $126.5 million, up 15 percent over 1959. Of this, $62.5 million represents instrumentation and controls including industrial control and nuclear instrumentation; the rest, $64 million, computers and data processing equipment.

In the industrial control market, most people consider Material Electrique de Controle et Industriele (MECI—rhymes with racy) the leader. The company manufactures a line that blankets the control field. Although wholly French-owned, MECI maintains close technical liason with the U. S.'s Leeds & Northrup. But the French company does more than copy L&N equipment. Practically every instrument is modified for French markets. For example, MECI's new line of transistorized 5-ma electric transmission equipment includes a temperature transmitter based on a L&N design and pressure and flow transmitters and recording pots of French design.

National production of instrument and controls does not satisfy the French market. The U. S. is still the top source of instrument imports. Expansion plans of established American owned foreign subsidiaries (Honeywell expects to triple its facilities in France) and new ones like Robertshaw-Fulton may change the pattern.

Practically everyone agrees that a big market for technically advanced control systems will continue to exist in France for many years.

How To Sell It

Although an increasing number of instrument and control companies are trying to sell this exploding European market, many companies are afraid of it. They tend to equate European selling with problems: competition with cheap labor, language difficulties, and transportation and communication delays.

International marketers who have tried it find that selling the European market is not as hard as it often looks. For example, take the popular bogeyman of cheap labor. There is no question that European labor rates are lower than similar ones in the U.S. E. P. McKenna of Ford International Div., Ford Motor Co., recently pointed out to a National Industrial Conference Board meeting that the average labor rate in the U.S. auto industry is $3.40 per hour, compared to an average of $1.15 in British auto plants, and $1.10 in German. But McKenna hastened to point out that *the labor cost of a completed car in the U.S. is only about 20 percent more than that in Germany or Britain because of the increased productivity in American plants.*

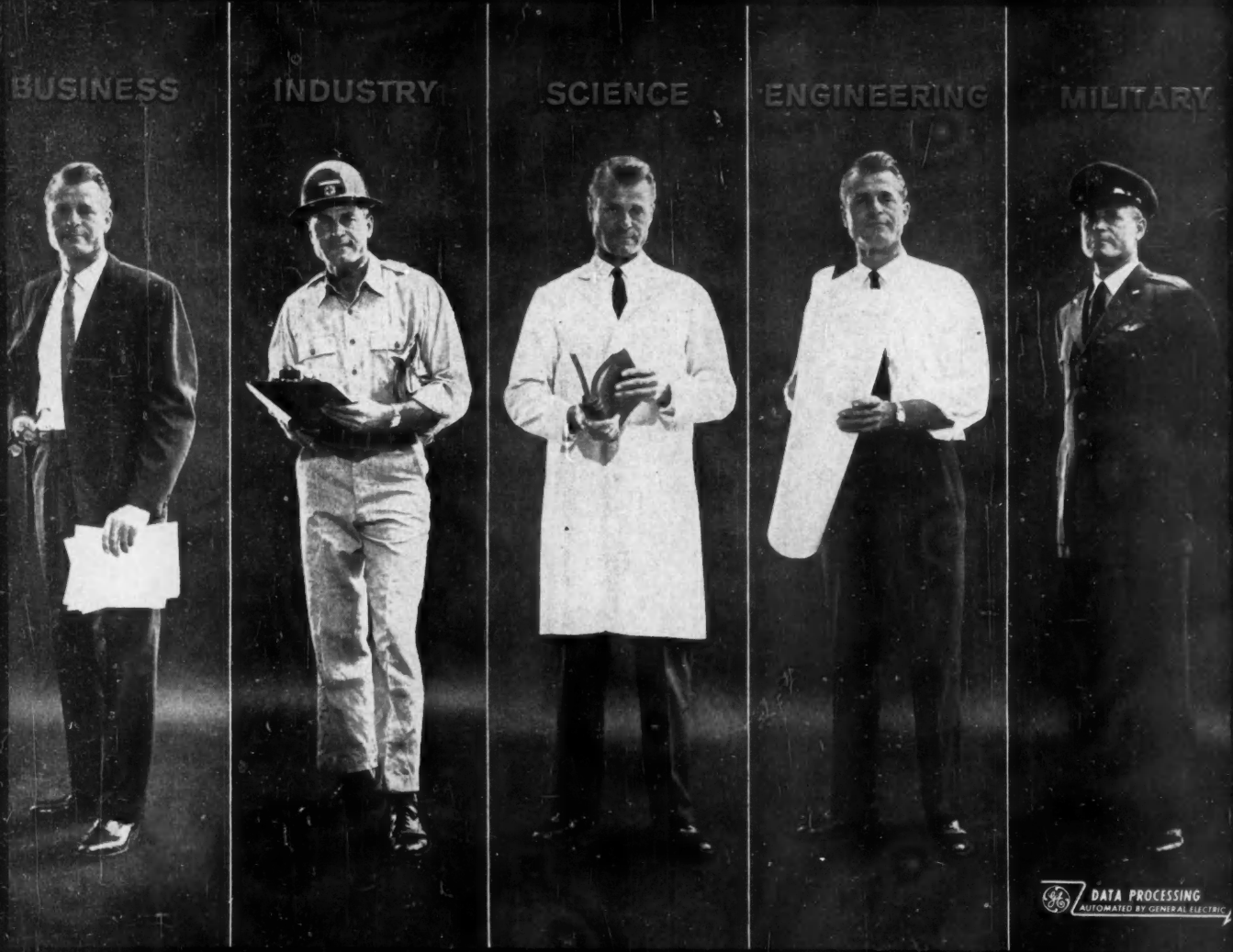
McKenna says that many raw materials are more expensive in Europe than in the U.S. Many components can still be built cheaper in the U.S. than in Europe because of large volume American production. It all adds up, says McKenna, to strong evidence that a U.S. company can compete in Europe, against European makers, with products manufactured in the U.S.

Most experts warn that a company may not be able to sell all of its products in Europe. *There is a better chance if the product is distinctive in design, made from sophisticated materials, or produced by highly mechanized production or patented process.*

Discussing the advisability of marketing U. S.-made components in Europe, another veteran marketer pointed out that Europe is overrun these days with Americans looking for European products they can sell in the U.S. *But you never run into anybody studying a European economy to determine what U.S. components can be sold profitably in Europe, he says.*

(Next month, Newsmen from Milan, Zurich, and Washington will report on European markets.)

NEW GENERAL ELECTRIC GE 225 INFORMATION PROCESSING SYSTEM... OFFERS YOU SYSTEM FLEXIBILITY FOR...



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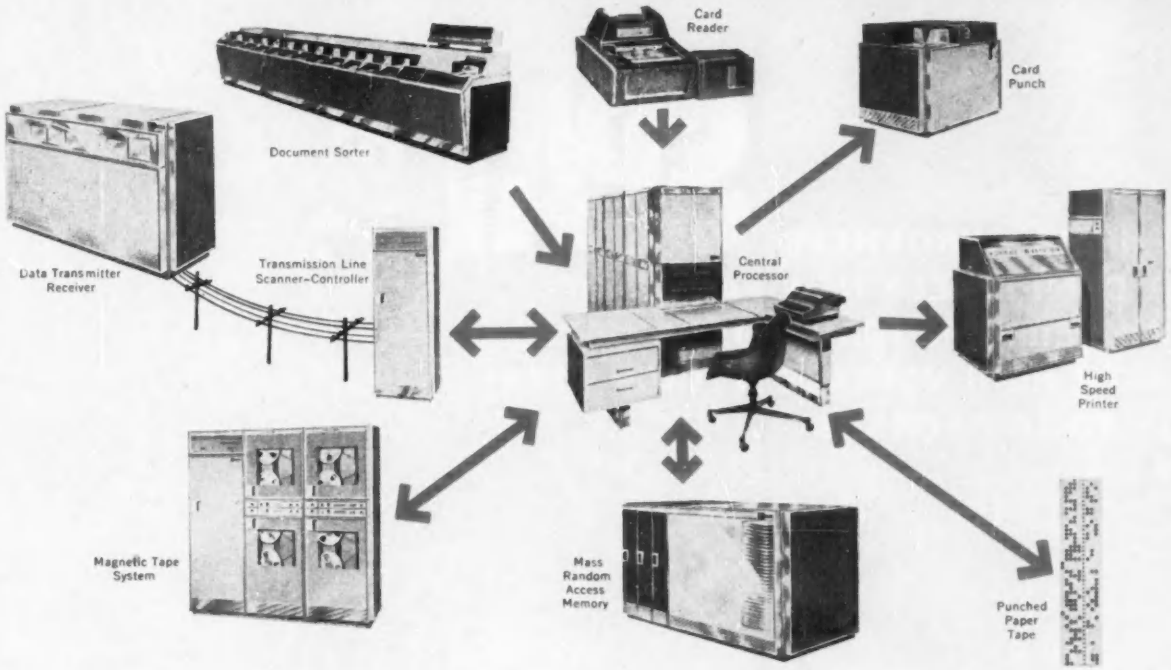
AUTOMATED BY GENERAL ELECTRIC



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provides greatest efficiency—maximum utilization of machine time.

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• High speed operation—25,000 five-digit additions per second.

• Compactness and low power requirements reduce cost of installation, site, air-conditioning, operation and maintenance.

• Practical for use in smaller firms where computer operation has heretofore been unfeasible.

• Full range of services available—programming aids package, training and consultation, back-up computer centers, and maintenance program.

For more detailed information, write today for brochure CPB-101 on the new GE 225 Information Processing System. Also available: brochure CPB-81 on the GE 210 Data Processing System.

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	V_{CBO}	P_{DISS}	I_{CBO} (10v) MAX.	h_{fe} (6v, 1ma) MIN.	h_{fe} (6v, 1ma) MAX.	f_T (6v, 1ma) MIN.
2N858	40v	150 mw	0.1 μa	15	75	5 mc
2N859	40v	150	0.1	30	120	6
2N860	25v	150	0.1	15	45	6.5
2N861	25v	150	0.1	30	100	7.5
2N862	15v	150	0.1	20	60	8
2N863	15v	150	0.1	40	120	10
2N864	6v	150	0.1 (6v)	25	125	16
2N865	10v	150	0.1	100	350	24

Completely new to the industry, these Philco Silicon Precision Alloy Transistors meet a widespread need for medium frequency, high voltage, high beta silicon transistors for both switching and amplifying applications. An exclusive new production technique . . . strip alloying . . . permits accurate measurement of the diode voltage rating and beta of every transistor during the manufacturing process. Never before has such close control in production been possible.

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CIRCLE 62 ON READER SERVICE CARD

Control
ENGINEERING

JANUARY 1961

One Show Would Do

"100,000 Jam Interkama" (International Congress and Exhibition of Instrumentation and Automation, Dusseldorf, September), shouted one story headline in this publication. "A record number of 42,000 visitors trudged through Los Angeles' new Sports Arena and an overflow circus tent" at WESCON (Western Electronic Show and Conference, August) reported another CtE story. "55,000 attended the annual IRE show in New York last March", the same story said. Yet a third story gravely stated, "Sparse Attendance Shakes ISA Show" (New York, September, for the exhibit was viewed by only 60 percent as many people as in 1959.

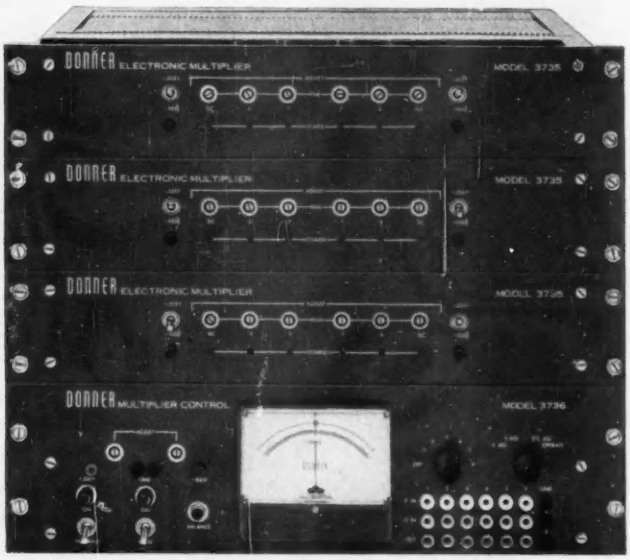
What is the significance of the inconsistency in attendance? Recession", grumbles one man. "Electronic shows are stealing the audience", worries another. But the sum of these snap answers does not equal the whole reason for a situation in which one exhibit skyrockets and another plummets. There are three more penetrating influences today:

- **Scope**—does any existing show offer a complete display of the new products available to the control field?
- **Novelty**—new products with new capabilities ought to be shown today, for the sidewise trend of capital investment gives creative control engineers both time and enough modernization money to apply innovations.
- **Frequency**—there are simply too many exhibits with too narrow scope.

Right now, January, 1961, is the time to examine the scope, novelty, and frequency of the shows through which an automatic systems engineer must prowl to attempt a complete view of control products. Because reduction in frequency is a step in the right direction, we compliment the ISA Executive Board for its plan to reduce, by 1962, to one national exhibit and one seasonal exhibit. But scope is not so easily adjusted, for the engineers will still need to attend WESCON and IRE to review developments in electronic components and test instrumentation. Moreover, he will see only a smattering of motor controls, switching devices, relays, and adjustable speed drives, unless he circulates to such industry shows as the Power Show and the Production Engineering Show. The existing shows will adapt to the extent that their loyal exhibitors will permit, but we doubt that any will adapt enough to become a showcase for what's new in the entire control field. Therefore we urge a fresh start. It is time to organize a show that would occur every two years, that would concentrate on new components and systems for control, and that would represent all segments of the control industry.

H. E. Vaughan

announcing...



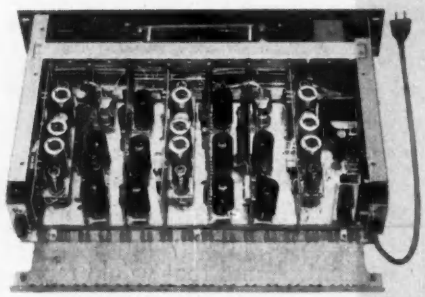
Illustrating three of the Donner Model 3735 Dual Electronic Multipliers (6 channels) associated with one Model 3736 Multiplier Control. This equipment provides 6 independent precision multiplier/divider channels, completely self-contained in only 15¾ inches of panel height.

the new Donner model 3735 dual electronic multiplier

with **0.01%**

SINGLE QUADRANT MULTIPLICATION & SQUARING ACCURACIES

Donner's new multiplier combines more most wanted features and high accuracies at a remarkably low cost. Check these features: **1.** 0.05% (FS) four quadrant multiplication accuracy. **2.** Completely compatible with all analog computers — no external power supplies or amplifiers required. **3.** Built-in division and square root operations. **4.** Modular construction with plug-in printed circuit cards. **5.** A 6 channel unit costs $3,800 or $633 per channel, compared to over $900 for comparable equipment.



The use of plug-in printed circuit cards in the Model 3735 Dual Multiplier assures adequate ventilation and easy access to all components. Shows 2 channel unit. Available in 2, 4, or 6 channels.

OTHER SPECIFICATIONS

INPUT Four independent voltages, X_1, Y_1, X_2, and Y_2 in the range of ±100 volts.

OUTPUT Two independent products, $-0.01X_1Y_1$ and $-0.01X_2Y_2$, in the range of ±100 volts at 10 ma maximum load current.

DRIFT Less than 100 mv over an 8 hour period.

NOISE Less than 100 mv, peak.

PHASE SHIFT Less than 1° at 100 cps.

ZERO ERROR With one variable = 0 and other ranging over ±100 volts, maximum error in product is only 40 mv.

DIMENSIONS Model 3736 Multiplier Control panel 5¼ x 19 inches.

Model 3735 Dual Electronic Multiplier panel 3½ x 19 inches.

Complete technical information on the Model 3735 Dual Electronic Multiplier is ready now. Call your nearby knowledgeable Donner engineering representative, or write Dept. 21.

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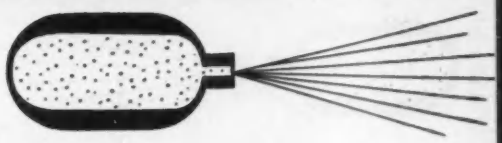


HOT GAS CONTROL SYSTEMS—I
Basics of Hot Gas System Design

THE GIST: This first in a series of three articles by Kidde engineers introduces the subject of hot gas controls by explaining why and where they are used. Author Schmidlin also delves briefly into the problems of designing gas power control systems. The next article will deal more specifically with hot gas servoactuator systems, and the third will cover hot gas reactive control systems. These articles will present the basic approach to the type of system, the choice of hot gas generator, and the choice of servovalves and other hardware to produce the best system. Typical system performance will be given as well as the analytical approach in system design and the analog studies leading to final system compensation.

ALBERTUS E. SCHMIDLIN
Walter Kidde & Co., Inc.

Hot gas is made up of the products resulting from chemical combustion or decomposition, producing energy in the form of gas mixtures at high temperatures and pressures. Hot gas is described as a fluid which has reached its state as a result of heat released from within. Thus by definition, high temperature air is not classified as hot gas, although the dynamic characteristics of both are similar.

Control systems using hot gas may be broken down into two classes: reactive and servoactuator systems. In the former, hot gas is directed in such a fashion that reaction forces cause, for example, a desired change in the attitude of an aerospace vehicle. Servoactuator systems might employ hot gas as the actuating medium to displace a linear actuator to position a vehicle's attitude control surface.

Why hot gas systems are used

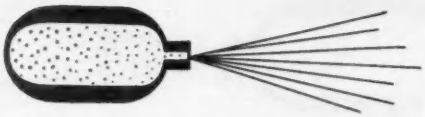
Hot gas systems are considered because of a combination of properties particularly needed in aerospace vehicles. They include:

• **Temperature capability**—High pressure pneumatics have long been studied to replace hydraulic systems in air vehicles in order to meet high temperature conditions. Although originally it seemed that the temperature problem was going to be a great obstacle in the space age, high temperature conditions are now isolated to specific areas of the vehicle and to particular parts of the flight profile. Equipment installed near the blast of the rocket engine, for instance, faces a high temperature problem. But modern thermal insulation introduces sufficient heat conduction lag so that equipment for intermittent operation may not experience high temperatures at all during the required operating time. Therefore the present-day ambient temperature requirement for hot gas equipment does not exceed the 275-400 deg F range. In the future, continuous duty on hypersonic vehicles will require equipment for ambient temperatures in the 1,000-2,000 deg F range. Also, hot gas systems are able to meet other extreme requirements of modern rocket environments.

• **Safety**—A big advantage over many hydraulic systems is the elimination of the fire hazard in the event of leakage.

• **Fast start ability**—The combination of vehicle complexity and the fast pace of launching calls for fast starts from each subsystem, a capacity possessed by hot gas systems. In addition, these systems are also capable of meeting the further requirement that this fast start be possible after indefinite storage times. Depending on the type of propellant (solid or liquid) and the type of ignition used, starting times ranging from a few milliseconds to a few hundred milliseconds are possible.

• **Light weight**—The gross weight at launch of space vehicles has become more important than it was for air vehicles. The suitability of hot gas systems where weight limitations are important is shown in Figure 1, where a picture is given of the installed weight vs operating time for different types of energy-producing systems. The high reliability of the air-bottle type of system is seen to be offset by its weight (and bulk). Though not shown on the chart, the self-containment of the air compressor system is offset by its weight, bulk, and



complexity. The hot gas generator, on the other hand, provides an extremely advantageous type of gas producer for the duty cycle seen in space vehicles.

• **High reliability**—Because of its simplicity, the hot gas system provides the ultimate in reliability. The newer solid propellants and new developments in liquid propellants offer a choice of characteristics so that specific requirements can be easily met.

• **Capacity for system integration**—Since weight and bulk, along with reliability, are so important in space vehicles, it is important to design systems so that each component can perform as many different functions as possible. By means of this cross-multiplicity of duties and a careful study of redundancy where needed, an optimum over-all system can be devised. Cryogenic fuels, for example, will undoubtedly play an extremely important role in future hot gas systems because of the fuels' capacity to perform a multiplicity of functions (Ref. 1).

The integrated auxiliary power unit and control system combination illustrates the possibilities inherent in the optimum use of propellant properties. In a cryogenic hydrogen-oxygen system, for instance, it is evident that this system can be used for refrigeration, for hot gas generation, to produce water needed for survival, as well as heat in the form of steam; and it can perform these duties on a continuous or intermittent basis. Thus the hydrogen and oxygen are employed in a continuous type of process system. In fact the hydrogen and oxygen combination as a gas or liquid probably will not be exhausted as such. The need for power actuation and the use of the byproducts of power actuation in an integrated space vehicle are so numerous and various that, by the time they are used for breathing, drinking, moisture for food production, equipment cooling or heating, bearing lubrication, accessory pressurization, guidance and control computing in gyros, etc., it seems there will be nothing to discard.

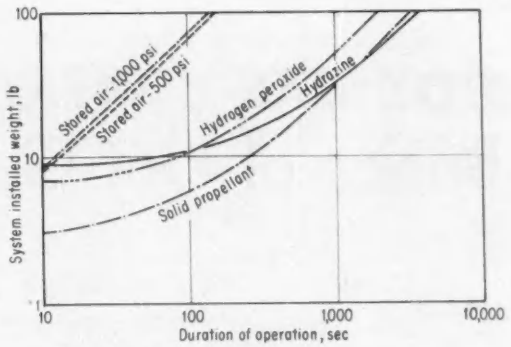


Fig. 1. Installed weight of air and hot gas systems as a function of duty time.

• **Performance**—An example of how the advantages of hot gas systems listed above can be employed in a high performance system is shown in Figure 2. The schematic is of an integrated cryogenic spacecraft system now under development at Walter Kidde. The pure gases are used in heat exchangers to cool other parts of the vehicle, and hydrogen is used in a reactive control subsystem to control the attitude of the craft. In addition, hydrogen and oxygen are combusted to drive a turbine that powers an alternator to provide electric power.

This is an example where no other control system medium could have filled the bill at all, let alone at the weight and size of a cryogenic gas system. In general, while there have been no instances of hot gas systems being substituted directly for hydraulics, gas systems have been shown to be equivalent in performance but with the added weight and space advantages, to say nothing of their storability, integration capability, etc.

The specific features of various propellants and gas generators will be discussed in more detail in

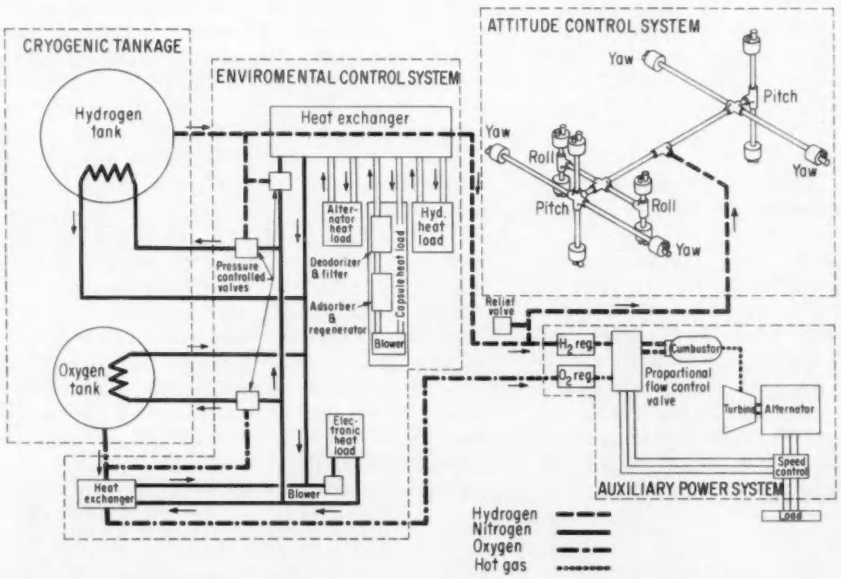


FIG. 2. Recently designed integrated gas powered system that provides refrigeration, attitude control, and electric power for a space vehicle.

Parts II and III of this series. At that time it will be evident that the present state of the art does provide suitable hardware that is being used in current missiles. Some of these applications are for relatively short life during launch or during reentry, but others are used intermittently over long periods of time.

Where hot gas systems used

Another example of the system integration described above is shown in Figure 3, which indicates a combination aerodynamic and reaction control employing the jet spoiler principle. In this case the hot gas disturbs or spoils the normal air flow over the control surface and acts as a fence or spoiler. Tests have shown that the jet spoiler continues to perform at higher angles of attack and Mach numbers than does the deflected surface type of control. Furthermore, the drag characteristics are favorable compared with those of conventional controls.

In addition, the reliability of such a system is advantageous since actually there is only one moving part: the valve which controls the hot gas flow. Also the mechanical equipment of a conventional control has been eliminated, and the stresses of the forces on the jet fence are no longer borne by the airframe of the vehicle. The change in the effective air pressure is felt on the control surface, of course, since this is the desired result of employing a spoiler. During aerodynamic flight this effect can be used to control the attitude of the vehicle. The only other force effect on the space vehicle itself is the reaction from the jet. It is this reactive force then which can be used in the same vehicle during space flight where there are no aerodynamic effects. This is an extremely simple type of control system which can be used for both segments of the flight profile: in the atmosphere and in space.

Another application of this principle is secondary injection for thrust nozzle vectoring control. By injecting a fluid into the side of the nozzle, downstream of the throat, the main propulsive stream is deflected off center. The side component of the thrust produces the force needed to correct the orientation of the vehicle. This technique can be applied as an on-off control or as a modulated type.

Perhaps more familiar is the technique of augmenting lift, rather than spoiling it, which is commonly called boundary layer control. Preliminary analysis of this phenomenon shows that a lift factor (ratio of actual increase in lift to reaction of the flowing jet) of 2.5 is possible (Ref. 2).

Hot gas systems have also been widely applied as servoactuator devices. These units are performing in the laboratory for vectoring rocket nozzles, positioning aerodynamic canard surfaces, and controlling jet vanes in rocket nozzle exhaust systems. The next section describes and illustrates several simple aerodynamic controls for positioning a control surface in various attitudes.

Starting the design

To meet system requirements in missiles and space vehicles, a higher standard of performance is needed than for the older, pneumatic servos. The use of hot gas in a servomechanism poses new problems for the control engineer. Hot gas cannot be considered simply as another fluid medium and cannot be substituted for the liquid in a conventional hydraulic system. The compressibility of a gaseous medium introduces a new variable which is not of critical importance in the hydraulic control system. The use of new techniques in pneumatic system compensation, however, has led to the development of practical controls which can be used in many aerospace vehicles.

The simplest type of system for aerodynamic control is the bang-bang or on-off system. The schematic of Figure 4A and the photograph, Figure 4B, illustrate such a system. The basic idea can be used in different ways. The most elementary type is one in which the control surface is positioned

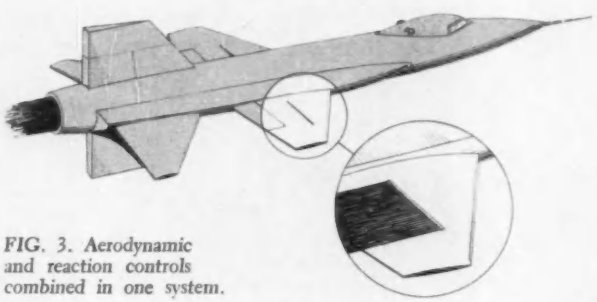


FIG. 3. Aerodynamic and reaction controls combined in one system.

in any one of three different positions: center, full right, and full left. Further refinement of the concept leads to another version. In effect this is a stepping-type device which, for that shown in Figure 5, provides six steps each to the left and right.

Typical response characteristics of these units are as follows: for the three-position type, a total response time of 30 millisec for full load hinge moment of 50 lb-in. and a hinge deflection of 15 deg. Typical for the stepping type are a hinge moment at maximum deflection of 50 lb-in. and a maximum deflection of 15 deg in six steps at a rate of 20 per sec.

For applications requiring faster response characteristics under high inertia loads, compressibility of the gas must be considered. If the gas is used in a piston-type device, the spring rate of the gas piston assembly influences the over-all spring rate and in practice determines natural frequency of the system.

In general the low natural frequency of a gas power actuator is not desirable when employed in a servosystem. An earlier CONTROL ENGINEERING

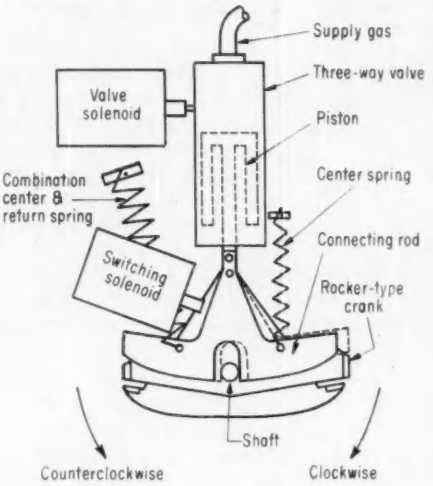
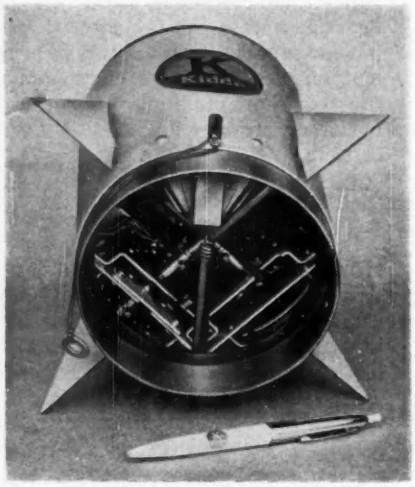


FIG. 4. A—Schematic of on-off vane control system shown in B—installed in the vehicle section.



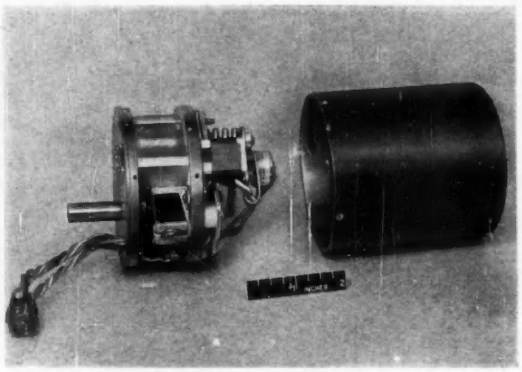


FIG. 5. Hot gas stepping-type device.

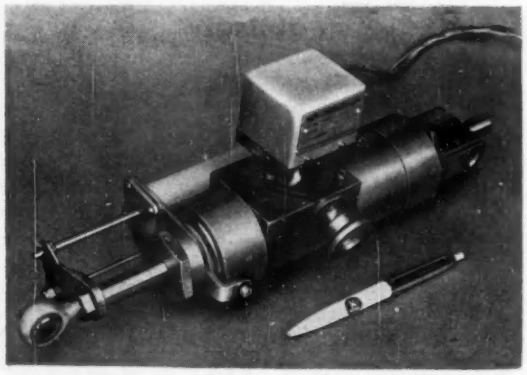


FIG. 6. Servoactuator used for rocket nozzle positioning.

article presented a comparison of the undamped natural frequencies of simple hydraulic and pneumatic systems (Ref. 3). This analysis showed that the bulk modulus of the medium has an appreciable effect on the undamped open-loop natural frequency. The expression for this frequency was given as $\omega_{ns} = (k_2 b + A^2)/k_3 m$. From the values given in Reference 3 it is evident that k_3, the fluid compliance, is the predominating factor. For the case presented there $\omega_{ns} = 428$ rad/sec for the hydraulic medium, $\omega_{ns} = 9.2$ rad/sec for the pneumatic. Closing the loop with proper compensation results in a marked improvement in the over-all performance of the system.

The servoactuator shown for rocket nozzle positioning (Figure 6) meets the requirements with a reasonable margin of safety. The requirements of this servoactuator are as follows: inertia, 42 lb-in.-sec^2; spring load, 38.5 lb-ft per deg; and response, flat to 3 cps. Testing has shown a 90-deg phase lag at 4.2 cps and an attenuation of 3 db at 5.0 cps. These results were attained with position and rate feedback paths, as will be shown in the second article of this series.

For the aerodynamic type of control, a frequency response of 15 to 20 cps is desired. In many of these systems, however, the inertia loads are much lower than those experienced in rocket nozzle positioning. Therefore the natural frequency of the gas power piston system is improved, but not enough to meet requirements. The requirements in this case are: surface deflection, 25 deg; inertia, 0.5 lb-in.-sec^2; spring rate, 8.3 lb-ft per deg; friction load, 200 lb-in.; response, flat to 10 cps. Typical response characteristics of a simplified canard system (no spring rate and zero friction loading) without compensation are shown in Figure 7. Test conditions and phase lags are listed in the accompanying table. Under load extremes the system does not meet the specification. A system meeting the requirements given above will be discussed in detail in the next article in this series, where analog

computer simulation studies will also be presented.

For vehicles traveling in space, since aerodynamic control cannot be used, the attitude of the vehicle must be controlled by some other means. Usually this is done by employing reactive forces acting on the vehicle to produce the motion needed to correct orientation. The simplest type of reaction control is one employing nozzles or thrust motors. Such devices have been proven in service and are employed in a system of the type shown in the schematic of Figure 8. These systems can be either on-off or proportional and have been used in both the cold gas and hot gas variety.

As one would expect, the use of good design practices based on fundamental knowledge of compressible gas flow is needed for proper system design in the reactive control system, just as it is for the piston-type servoactuator. Long transmission lines, for example, introduce a transport lag of 1 millisec per ft ideally for the first impulse and an additional time lag for complete stabilization of the system during flow. In actual practice, however, pneumatic transmission lines are not ideal and actually attenuate and distort the signal so that the first impulse sometimes takes twice the ideal transport time (Ref. 4). Furthermore, transient pressure phenomena at the nozzle are affected by the relative proportions of lines and valve sizes. Work done on cold gas systems by the National Bureau of Standards indicates that unusually high pressure pulsations can persist for periods of time approaching 10 millisec in relatively long lines. Here long lines are defined as approximately 40 in.

Other work at NBS analyzes upstream and downstream line lengths of approximately 20 diameters from the control valve. The results shown in Figure 9 indicate that the shock front in the downstream section can approach the original pressure upstream of the control valve even though the total

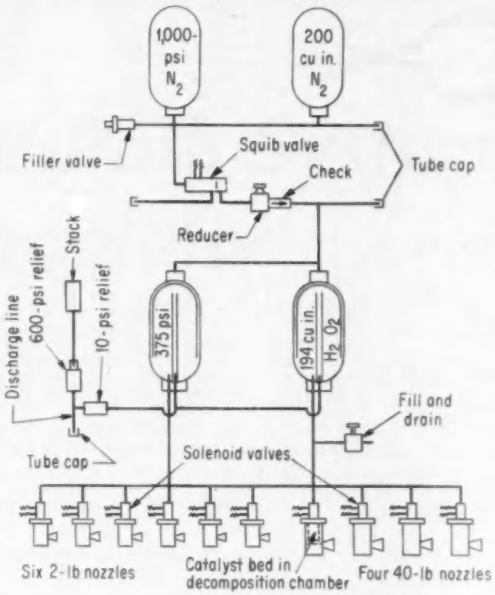


FIG. 8. Third stage reaction control system for the Scout missile.

volume occupied by the gas is doubled and the inlet flow to the system is zero. Such peaks occur for Case I where the control valve is assumed to open instantaneously and offer zero restriction to flow. For smaller valve areas it is obvious that the peak pressure will be reduced. For the extreme Case III the filling time of the downstream tube is such that a step-by-step pressure transient develops. For a pulse-type reactive control system, neither the high pressure peak nor the stepped transient rise is desirable because the transient period represents an appreciable part of the total pulse time. Therefore, it is most desirable to have a short rise and a minimum overshoot. It would seem that Case II approaches the ideal for a reactive control system. The graphs represent extreme cases since the test

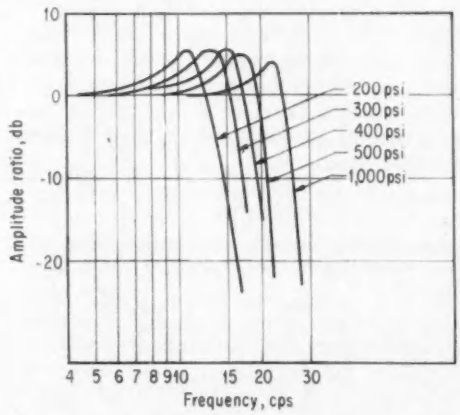


FIG. 7. Frequency response of a closed-loop canard system tested uncompensated with hydrazine using restricted bleed servovalve. Test conditions and phase lags are given in the table.

CANARD SYSTEM TEST

Supply Pressure	Temperature	Phase Lag 45 deg	Phase Lag 90 deg
(psi)	(deg F)	(cps)	
200	760	7	11
300	890	8	11.5
400	990	8	13
500	1,050	8	13
1,000	1,150	8	13

TEST CONDITIONS

Fluid: Hydrazine, 1,800 deg F in chamber
Supply pressures as noted
Ambient Temperature: 70 deg F
Load Inertia: 0.5 lb-in.-sec²
Load Spring Rate: none
Rate: none
Input Amplitude: ±0.135 in. (±4.4 deg)
Feedback Gain: 265 ma/in.
Maximum Canard Rotation: ±28.1 deg
Radius Arm: 1.75 in.
Piston Area: 3.14 sq in.

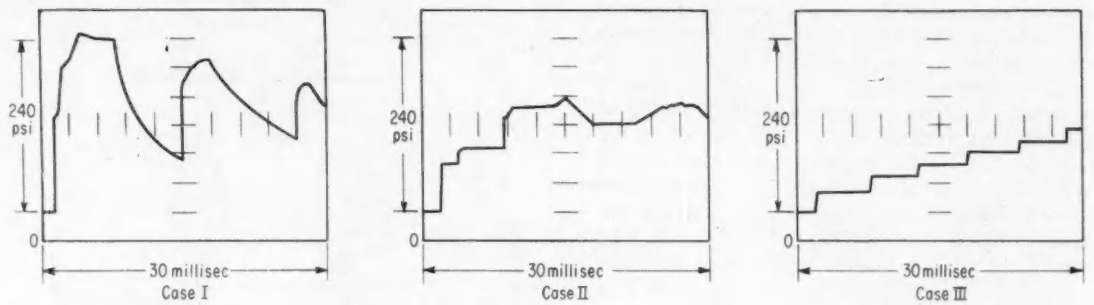


FIG. 9. Transient pressure at the nozzle as a function of valve to pipe-area ratio: Case I—No restrictions; Case II—Restriction area, $A_{ra}/A = 0.268$; Case III—Restriction area, $A_{ra}/A = 0.067$.

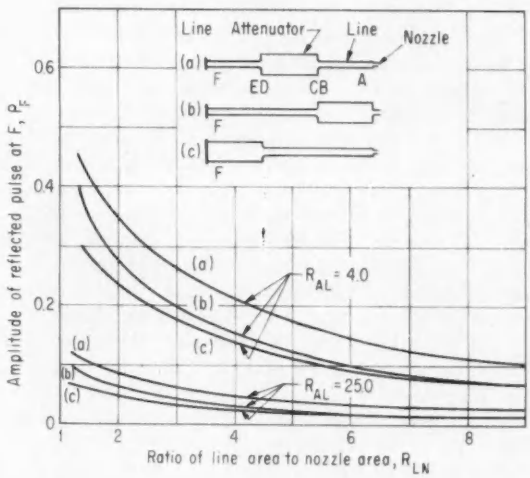


FIG. 10. Effect of geometry of the transmission line on reflected pulsations. R_{AL} = ratio of cross sectional area of the attenuator to that of the line; $p_F = (p_o - p)/p$, where p = pressure, p_o = reference pressure, both in psia.

and analysis were conducted assuming zero flow at the nozzle, that is, a dead end condition at the nozzle and zero flow input at the supply end. Also the analysis was based on a control valve midway between the source and the nozzle, with approximately 20 diameters upstream and downstream. So from a reactive control system point of view, the results represent extreme conditions which usually can be avoided by proper system design.

The pressure transients mentioned above indicate phenomena which occur at the nozzle. Further NBS research illustrates the transient conditions which persist at the gas supply end of a pneumatic transmission line. The work in this study was intended to provide information which would minimize the undesirable pressure transients at the inlet end of a transmission line. This analysis, including reflected waves, led to Figure 10. The results show that to minimize the amplitude $p_F = (p_o - p)/p$ of reflected waves at the supply end of the transmission line, point *F*, an attenuator volume should be installed at that point. From a response standpoint, however, this introduces a large time constant at the nozzle end. Therefore it is recommended that the system design as shown at (b), that is, with the attenuator volume at the nozzle be used as the best compromise. It is interesting to note that arbitrary location of the attenuator at some point near mid-span represents the worst condition relative to this phenomenon.

The above considerations must be taken into account in the preliminary design stage of the reactive control system. The configuration of the vehicle must be studied carefully and an early choice made between centralized gas generators with distribution lines vs integral motor and gas generator designs.

The hot gas type of control meets the most stringent conditions of light weight, compact size, and high reliability. In production, for example, is a typical hydrogen peroxide thrust motor of 44-lb thrust with a response time of 30 millisec from electrical impulse to 90 percent of rated thrust. This motor is used in the third stage of the Scout missile and has the capability of being actuated repeatedly in space with hydrogen peroxide for a period of over 48 hr. Such motors are presently available in sizes from ½ to 600 lb thrust.

REFERENCES

1. *SPACECRAFT POWER FROM OPEN-CYCLE CHEMICAL TURBINES*, Antonio Orsini, "Astronautics", Volume 4, Number 12, December 1959.
2. *INVESTIGATIONS OF THE BOUNDARY LAYER CONTROL ON FULL SCALE SWEPT WING WITH AIR LED OFF FROM THE TURBO JET*, P. Rebuffet and P. Poisson-Quinton, NACA TM-1331, April 1952.
3. *SELECTING POWER CONTROL VALVES—II*, J. L. Shearer and S. Y. Lee, "Control Engineering", April 1956.
4. *CONTROL SYSTEM COMPONENTS*, Gibson & Tuteur, McGraw-Hill Publishing Co., Inc., New York, 1950.
5. *HIGH PRESSURE PNEUMATIC SYSTEMS FOR INDUSTRY*, A. E. Schmidlin, presented at Purdue University Control Systems Components Conference, May 1959.

New Continuous Path System Uses DDA Interpolator

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THE GIST: Using digital differential analyzer techniques, this completely transistorized machine control system is capable of both linear and circular interpolation. The circular-interpolating ability adds two major advantages: 1) computer time required for tape preparation is reduced since the need for approximating circular arcs with small straight line segments is eliminated, and 2) parts consisting of arcs of circles and straight lines can be programmed without computer assistance. As in previous Bendix continuous path systems, the interpolator is connected directly to the machine tool servo drives without an intermediate tape link. The semiabsolute position-transducing system is of the phase analog type using resolvers as feedback devices. With a typical resolution of 0.0002 in., maximum cutting rates exceed 200 ipm for straight lines with a maximum circular rate of one-half the linear rate.

The Bendix Dynapath system is a continuous path machine tool control unit capable of linear and circular interpolation. Information is supplied to the control unit on eight-channel plastic punched tape via either a mechanical or photoelectric tape reader. The control unit is completely transistorized and utilizes modular plug-in construction for ease of maintenance. An operational test program is built into the control to facilitate preventative maintenance (similar to maintenance provisions included in the Bendix system described in Reference 1).

In a control unit capable of only linear interpolation, arcs are approximated by many short, straight-line segments. Thus many separate commands must be generated by the computer being used for tape preparation. Adding circular interpolation to the control unit allows a circular arc to be generated with a single command, and computer time is reduced accordingly. If it is expected that parts consisting mainly of straight lines and circular arcs are to be cut, a less expensive mechanical tape reader may be capable of meeting the input data rates of the control system. Without circular interpolation, a high speed photoreader is a necessity if reasonable feed rates are to be attained on arcs.

When simple parts consisting of straight lines and circular arcs only are to be cut, it is possible to prepare or modify tapes without the use of a general purpose computer. Cutter-center offset and feed number computations must be handled by the tape programmer. Feed number calculation has been made relatively simple with the aid of nomographs available from Bendix.

Input information is recorded on standard eight-channel punched tape. This information may be in either straight binary code or in binary-coded-decimal form. The choice of Dynapath with linear interpolation and straight binary code input will allow interchangeability of tapes with previous Bendix continuous path systems. Circular interpolation requires additional data on the tape. The binary-coded-decimal format is useful in that it allows the preparation and modification of simple control tapes using only a Flexowriter. An address type of format is used with individual codes being in agreement with those of the Model FPC-8 Verifier Flexowriter. All characters used are approved by the EIA's Subcommittee TR 24.1.2 on numerical controls.

The serial binary digital differential analyzer uses magnetostrictive delay lines for dynamic storage. Its transistorized construction leads to more reliable and lower volume circuitry, consumes less power (about 750 watts for a typical three-axis control), and can be kept at optimum temperatures with a simple closed cooling system.

Linear interpolation with a DDA

A unique feature of this system is the serial DDA using magnetostrictive delay lines for dynamic storage. The simplified logical drawing in Figure 1 will be used to explain DDA interpolation.

The *R* line and *I* line are magnetostrictive delay lines in which pulse data is continuously recirculating. The number of binary bits that may be stored on a line is equal to the system clock frequency times the time delay. Thus, on a 400-microsec delay line

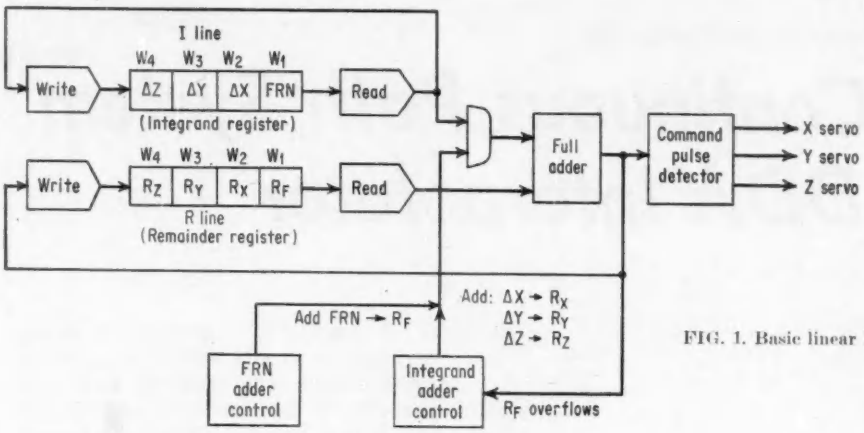


FIG. 1. Basic linear DDA interpolator.

operating at a clock frequency of 200 kc, 80 binary bits may be stored. Assume this is broken up into four 20-bit words. A timing generator, which generates four word time signals, W_1 through W_4, during each complete circulation of the delay lines, allows each word to be uniquely identified as it passes out of the read amplifiers. The combination of the *I* line (or integrand register), *R* line (or remainder register), and adder act like an integrator in a conventional DDA, integrating the contents of the integrand register with respect to the input to the adder. (Reference 2 gives a clear explanation of DDA operation).

Information is stored on the delay lines in straight binary code, with the least significant bit of each word appearing first at the read amplifier output. In the W_1 position of the *I* line is stored a feed rate number. In W_2, W_3, and W_4 are stored the component distances, ΔX, ΔY, and ΔZ, respectively, of the motion to be accomplished.

In accordance with conventional DDA operation, the integrands ΔX, ΔY, and ΔZ are added periodically to the contents of the remainder registers, R_X, R_Y, and R_Z, respectively. The feed rate number in W_1 establishes the rate of addition. Each time, the integrands are written back on the *I* line unchanged, and the new sums instead of the previous values are written on the *R* line. The overflow pulses from each *R* register are used as command pulses to the appropriate machine servo, each pulse typically representing 0.0002 in. of slide motion.

There are two requirements for linear interpolation between two points: 1) the velocity vectors for the axes involved must be proportional to the distance to be moved in the respective axes, and 2) motion must be terminated at the correct end point. Consider how the operation just described satisfies the first of these criteria.

If the *R* register starts at zero and the integrand is added to *R* repeatedly, overflow (output) pulses will be generated at a rate approximately uniform with respect to the add operations; and if several such operations are going on independently (in two or three axes for example)—except that any instruction to add is obeyed by all simultaneously or one after the other—the output pulse rates from the integrators are proportional to their respective integrands. The actual value of these rates is established by the rate at which add commands are generated. Thus in a two-axis machine control, a straight line of arbitrary slope can be traced at an arbitrary speed, depending on the frequency of adding and limited to a rate of one addition (and one command pulse per axis) per iteration. The first requirement for linear interpolation is satisfied.

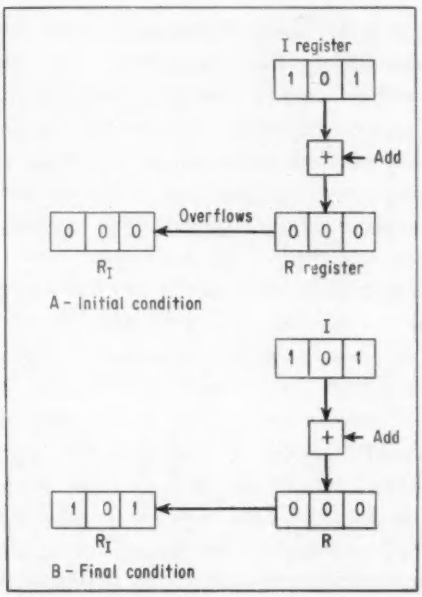


FIG. 2. Terminating a linear interpolation block.

The feed rate number (*FRN*) in W_1 of the *I* line controls the add rate for the ΔX, ΔY, and ΔZ integrands. *FRN* is normally added into W_1 of the *R* line once per iteration. Overflows from the R_X register (W_1 of the *R* line) are used to generate add commands for the ΔX, ΔY, and ΔZ integrands. The rate at which *FRN* is added into the *R* line may be reduced smoothly to 20 percent of the normal rate

by the operator using the feed rate override control, thereby reducing programmed feed rates accordingly.

The problem of terminating motion at the correct end point is the second requirement for linear interpolation between two points. The solution may be understood by first recognizing that the process of addition that has been described is really a multiplication process. For example, if the number five is added into an initially empty register four times, the sum is equal to the product of 4×5. Also, with binary numbers, a number is multiplied by two by shifting it one position to the left, adding zeros into the position furthest to the right.

Now consider that the storage capacity for integrands and remainders is limited to three bits, as shown in Figure 2, and that the number five is stored in the I register. Further assume an imaginary three-bit register R_f which is merely an extension of the R register, receiving as its input the overflows of the third-bit position of R. Figure 2A shows the contents of all three registers before any additions have taken place. Figure 2B shows the registers' contents after five overflows have occurred, since the R_f register holds the number five. It is obvious that this end condition can be attained by inserting the number five into the R register and shifting it left three positions, which in effect multiplies the number by eight. Also it is apparent that this end condition may be reached by adding the contents of the I register into the R register eight times, exactly equivalent to the previous operation. The termination problem is therefore reduced to detecting when an integrand of N binary bits has been added to the remainder register 2^N times.

Circular interpolation with a DDA

If circular interpolation is desired in the X-Y plane, it is necessary to supply to the control unit the X and Y components of the initial radius vector and the X and Y components of the final radius vector, Figure 3, and the direction of the circle, clockwise or counterclockwise. As in the linear case, interpolation is done by repeatedly adding the integrands into the corresponding R registers. The

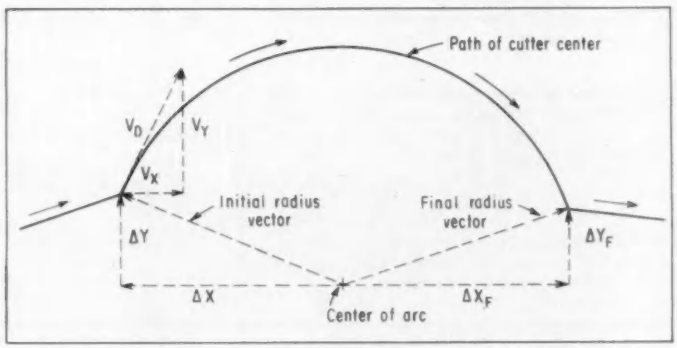


FIG. 3.
Defining a circular arc.

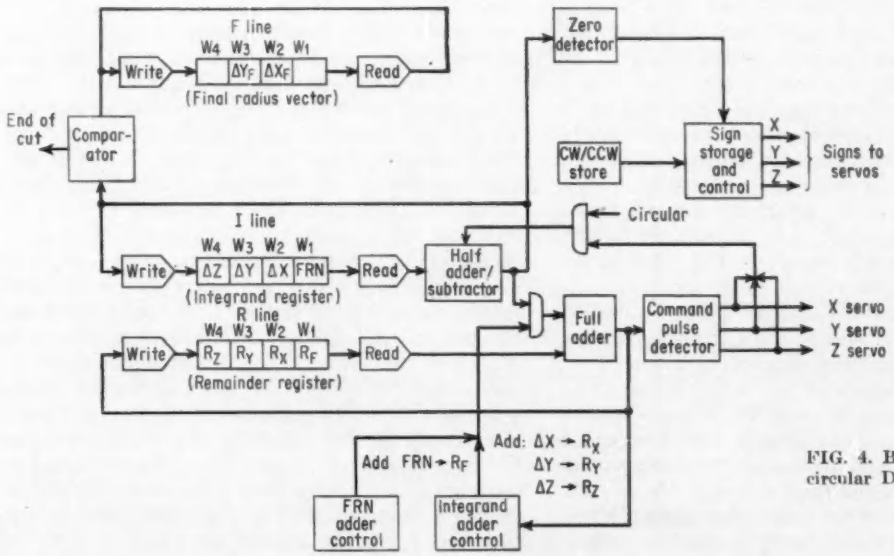


FIG. 4. Basic circular DDA interpolator.

FIG. 5. INPUT DATA CONVERSION ROUTINE

Read $\Delta X = 0.0026$ in. and $\Delta Y = 0.0118$ in. in binary-coded-decimal form, convert to straight binary, and store in 10-bit registers. Add identification pulse and perform shift operation.

OPERATION		REGISTER CONTENTS
1. I_X register initially empty		0 000 000 000
2. Recognize sign character of ΔX and store separately. Ignore decimal point and leading zeros		
3. Read 2 = 0010 into leading or least significant end of I_X register		0 000 000 010
4. Recognize 6, but do not read. Then simultaneously pass I_X through one-unit and three-unit delays and place sum of delay outputs in I_X register	$2 \times 2^1 = 4$ $2 \times 2^3 = 16$ 20	0 000 000 100 0 000 010 000 0 000 010 100
5. Add 6 = 110	6 26	0000 000 110 0000 011 010
6. Load ΔY into I_Y register in same manner, finally obtaining	118	0001 110 110
7. Add marker pulse into least significant bit position, effectively dividing numbers by two and thus converting from inches to pulses		Least significant bit; Marker pulses
	ΔX	0 000 011 011
	ΔY	0 001 110 111
8. Shift both numbers back repeatedly (in this case three times) until a "one" is located in the last (most significant) position of one of the registers		Marker pulse
	ΔX	0011011000
		Original number/2 = 13
		Marker pulse
	ΔY	1110111000
9. The temporary storage registers now hold the command numbers in the form needed for the DDA interpolator		Original number/2 = 59

slope of the velocity vector, V_0, which is tangent to the circle, is the negative reciprocal of the radius vector slope. Thus overflow pulses generated by adding ΔX into the R_X register are Y command pulses while the overflows from the R_Y register are X command pulses. Since the slope of the velocity vector continually changes as a circle is traversed, the radius vector slope must also continually change. This is accomplished by modifying the integrands each time that a command pulse is generated so that ΔX and ΔY continually represent the components of the rotating radius vector. The necessary one-pulse modifications to ΔX and ΔY are accomplished by a half adder/subtractor in the I line recirculation loop as shown in the block diagram of Figure 4.

The final components of the radius vector, ΔX_F and ΔY_F, are stored in W_2 and W_3 of the F line in Figure 4. These final components remain constant during the interpolation process. A continuous comparison is made between the integrands ΔX and ΔY and the components of the final radius vector. When these quantities are equal, both in absolute magnitude and sign, the operation is terminated.

Because the slope of the velocity vector changes sign at each crossing of an axis, it is necessary to provide a sign control feature in addition to pure sign storage when circular interpolation is desired.

Input conversion

When tape data is in binary-coded-decimal form, it must be converted to straight binary before the interpolation can proceed. This is done during the tape reading operation when new axis commands are being loaded into the temporary storage section of the control. A four-word magnetostrictive delay line is used for temporary integrand storage.

The axis commands on the tape indicate the desired travel in inches. In a 0.0002-in. resolution system each command must be defined to four decimal places and must end in an even decimal digit. Trailing zeros must be punched on tape. Leading zeros and decimal points may be punched if desired. Therefore, 0.0124 and 124 are identical commands.

Figure 5 shows how a number is read from the tape in binary-coded-decimal form, most significant bit first, and converted into straight binary. After a command number is completely read in and converted, the number's least significant bit occupies the leading bit position, i.e., appears at the read amplifier during the first pulse period of each word. Since the numbers in the delay lines at this time represent the desired commands in 0.0001-in. units, they must be divided by two to convert to an equivalent number of 0.0002-in. pulses. Since the command numbers are always even, the least significant bit position of each storage register always holds a zero at this time. The division is therefore accomplished by writing the identification or marker pulse into the least significant bit position and thereafter using the bit following the marker pulse as the least significant bit position. Then if linear interpolation is required, both command numbers are shifted back repeatedly (in effect multiplied by two each time), one bit position per iteration, until the

most significant bit of the largest number reaches the last bit position of that word. Locating the command numbers at the trailing or most significant end of the registers permits the interpolator to generate maximum output pulse rates for a given iteration rate.

When a circular interpolating command occurs, the final radius vector components ΔX_F and ΔY_F are read into a second temporary storage delay line in the same manner. The final radius vector components are shifted at the same time as the initial components. However, in this case the shifting continues only until the most significant bit of the largest initial radius vector component reaches the next-to-last pulse period of that word. The reason for this is that during circular interpolation, the largest of the integrands ΔX and ΔY can exceed its initial value by a factor of 1.414 (in worst case of 45-deg slope of initial radius vector). To provide space for this possible increase of integrand length by one bit, the shifting must be halted one bit position earlier. This limits the maximum radius that can be specified to one-half the maximum straight line and reduces the maximum speed of circle generation by the same factor with respect to straight-line generation in any given system having both types of interpolation.

The feed rate number is read into temporary storage and converted in a manner similar to that previously described, except that it is not shifted as are the command numbers.

The system applied to a milling machine

The Bendix Dynapath contouring control shown in Figure 6 was designed to operate a Pratt & Whitney Numeric Keller BL 3622. It is capable of linear interpolation in all three axes and of circular interpolation in the X and Y axes (longitudinal and vertical). The tape format is binary-coded-decimal.

A block diagram of the control system is shown in Figure 7. There are four delay line registers. The *F*-line register holds the active and temporary final radius vector values for circular interpolation. The I_t, I_a and *R* registers hold the temporary incremental axis commands and feed rate, active incremental commands and feed rate, and the axis and feed rate remainders, respectively. The input conversion routine is performed by a separate adder in the input logic network with the *F* and I_t registers.

The type of interpolation in a block, linear or

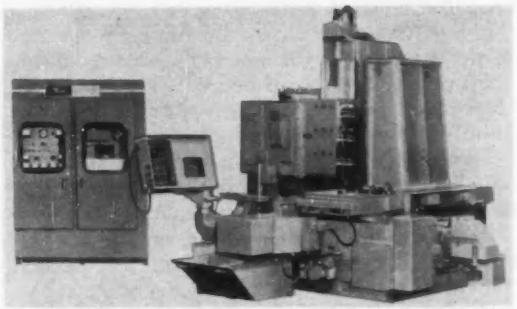
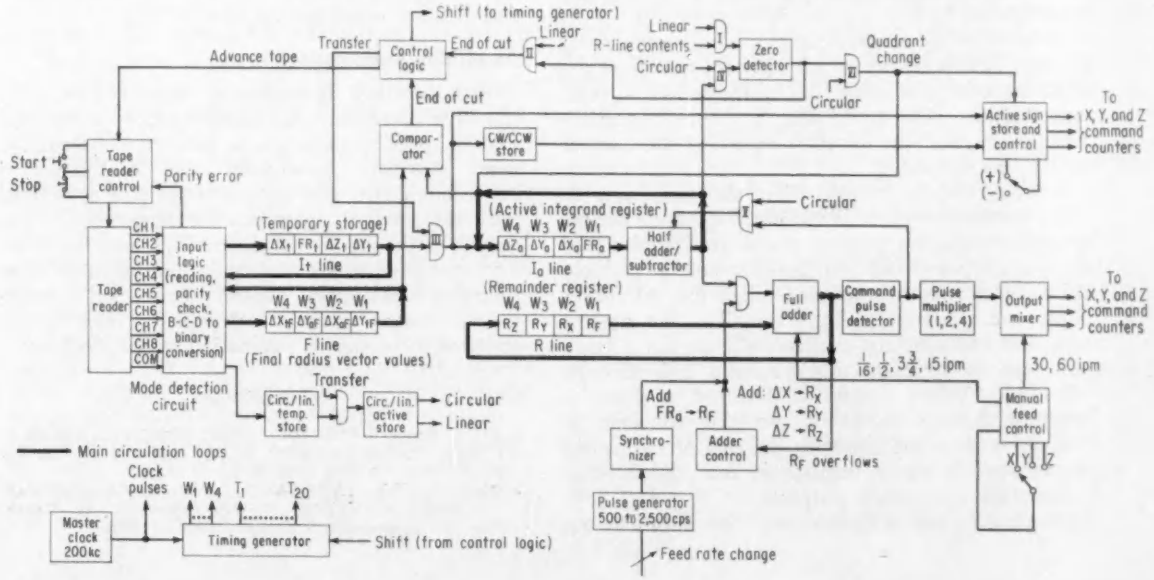


FIG. 6. Dynapath system on P&W Numeric Keller milling machine.

FIG. 7. Block diagram of system for machine shown in Figure 6.



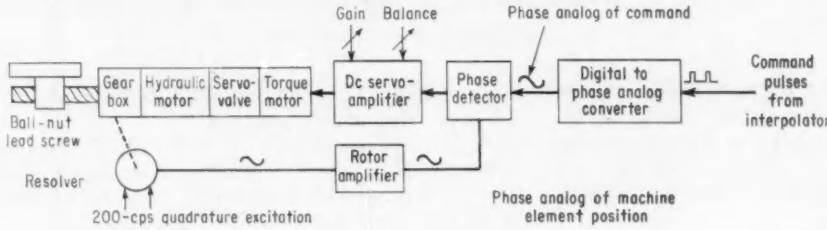


FIG. 8.
Phase analog servo.

circular, is detected by the mode detection circuit which gates through either a circular or linear signal depending on the mode of the active cycle. This signal activates one input of the proper two-input AND's throughout the data processor, setting up the system for the correct mode of operation.

In the linear mode the contents of the I_a register are added into the R register in the full adder at a rate depending on the feed rate FR_a. Command pulses are generated. This continues until the zero detector (receiving data through AND-I) emits a signal indicating the end of the cycle has been reached. This signals the control logic through AND-II, transferring data from temporary register I_t to active register I_a through AND-II and advancing the tape. At this point a shift signal to the timing generator shifts the data in I_a by two word lengths so that it is in proper sequence. Command signs are stored in the active sign store so that they are continuously available.

Feed rate for a given cycle depends on FR_a in the I_a register as read from the tape but can be modified by the machine operator if desired. To operate at the tape-coded feed speed, FR_a is added to R_F each iteration. R_F overflows are detected and cause the full adder to add ΔX_a to R_X, ΔY_a to R_Y, and ΔZ_a to R_Z. The operator can modify this by adjustment of the variable-frequency pulse generator.

Without additional manipulation, maximum feed rate is achieved by adding the X, Y, and Z contents of the I_a into the R register once per iteration. Higher speeds are obtained by multiplying the command pulses by 2 or 4 in the pulse multiplier.

Essentially the same procedure is followed during circular interpolation except that R_X overflows are Y command pulses and R_Y overflows are X command pulses. The mode detection circuit indicates circular so that the circular inputs to the various AND's are activated.

During circular interpolation the final sign to the command counter in the servo depends on the integrand signs and the cw or ccw command stored in the cw/ccw store. As pointed out, a problem arises in circular interpolation when the cut moves from one quadrant to the next. To take care of this, the zero detector continually looks for a quadrant change by examining ΔY_a and ΔX_a through AND-IV. When a zero is detected, a signal is emitted through AND-VI, changing the sign in the active store and changing the sign of the proper component in the I_a register so that the latter is correct for comparison purposes.

Since ΔY_a and ΔX_a represent the instantaneous components of the radius vector they must be continually modified during a circular interpolation cycle. Command pulses are gated through AND-V, causing the half adder/subtractor to continually perform this modification. In turn, ΔY_a and ΔX_a in the I_a register are continually being compared with the final radius vector values ΔY_{aF} and ΔX_{aF} in the F register by the comparator. When coincidence is achieved the comparator emits an end-of-cut signal.

Phase analog servo

The command pulses from the output mixer are converted into a phase analog of the command in the phase analog servo of Figure 8. The analog command is compared with the phase analog of actual machine position generated by the phase shifting resolver driven from the lead screw gear box. As a result of this comparison in the phase detector, a dc signal is generated with a magnitude and polarity corresponding to the error between commanded and actual position. The error voltage drives a conventional electrohydraulic servo which positions the machine element through a ball-nut lead screw. Each axis has a complete phase analog servo except for the resolver excitation equipment which is shared by all axes.

The phase analog electronics is accurate to one part in a thousand. Thus in a system having 0.0002-in. resolution, the resolvers are geared to the machine lead screws so as to cause one full revolution of the resolver shaft for each 0.2 in. of slide travel. Excess error detecting circuits are provided which detect and indicate errors approaching ± 0.1 in.

Auxiliary functions

Such auxiliary functions as coolant flow, chip conveyor operation, tool changes, table index, and spindle speed change can be programmed into the tape. Auxiliary commands may be performed immediately after they are read from tape or delayed until the previous command has terminated. The output of the auxiliary function logic may be either a momentary contact closure for pulling-in or dropping-out locking-type control circuits or a maintained contact closure which may be reset by the operator or by signals originating at the machine.

REFERENCES

1. *FIVE CASE STUDIES SHOW EFFORTS TO SIMPLIFY MAINTENANCE*, B. K. Ledgerwood, "Control Engineering," March 1960, p. 129.
2. *COMPARING INTEGRAL AND INCREMENTAL PROCESS CONTROL COMPUTERS*, E. L. Braun, "Control Engineering," January 1960, p. 113.

Multiple Columns in Chromatography

THE GIST: Using more than one separation column in a gas chromatograph enhances the advantages of this stream analyzer for the operation and control of process plants. Multiple columns can:

- **speed up analysis of key components in the stream sample**
- **improve resolution of total sample analysis**
- **augment the sample to give a favorable components ratio for trace analysis**
- **protect columns from exposure to damaging stream components**

The authors detail the column storing and column backflushing techniques for obtaining these benefits. They also point out, however, that these improvements are not obtained without some offsetting penalties like the need for more elaborate valve programming and complicated hardware in the chromatograph.

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Monsanto Chemical Co.

Early process gas chromatographs were single column instruments (Reference). While useful in a number of simple cases, such analyzers left something to be desired in many other applications. A single column often may not separate all the desired components of the sample, or the column may be attacked or rendered unstable by some sample component. Furthermore, since an operator usually needs a reading of no more than one, two, or at most three components of the stream for control purposes, a valuable analyzer is one which would read out the components of interest in the shortest time while disregarding the other stream components as much as necessary. A logical technique for speeding analyses and protecting columns is multiple column chromatography—employing column storing, column flushing, or both.

Column storing is usually used to obtain a complete analysis within a reasonable time rather than one or two sample components in the shortest possible time. Column storing employs at least two separate columns, with one column switched out of a carrier flow system at some specific time in the analysis to store whatever sample components are in the column until that column is returned to the carrier flow system. This technique permits using columns which are preferable for particular sample components but unsatisfactory for others.

Column flushing techniques are used primarily to supply rapid analyses of a few components as needed for process control work. Column flushing involves switching a column out of the carrier flow system and admitting to it a separate flowing stream of carrier gas either in the normal or reverse direction. The flushed-column effluent may be sent through the detector or discarded. A variety of combinations are possible with this technique.

In perhaps the simplest case, that of a single column, the faster-moving sample components are allowed to pass through the column and into the detector. Then with the slower-moving components still in the column, the carrier flow is reversed through the column. As the effluent passes through the detector, a single peak—composed of all remaining components—results, giving a total rest gas analysis provided the backflush flow rate is properly adjusted. Or if desired, a separate carrier stream may be used and the column backflushed to vent, clearing the column of unwanted sample components prior to the admission of the next sample.

A slightly more complicated version of the chromatographic backflushing technique is to use a single column (which is permanently in the carrier flow system) in conjunction with a backflushed column. The permanent column can be before or after the backflushed column, permitting backflushing of the first or second column in a dual column system.

Column-switching valves

Essential to the success of any multiple column chromatograph installation are well designed and appropriate column switching valves. A valve will be required for each column to be removed from the system. Basically, storing requires a six-port valve and backflushing an eight-port valve.

Originally, column storing was done with three-

* Now with Greenbrier Instruments, Inc.

Basic Switching Valves for Multiple Column Chromatography

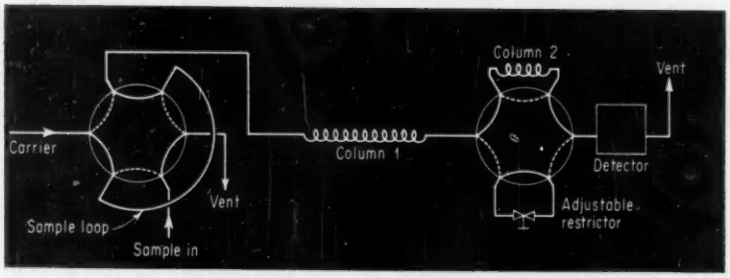

FIG. 1.

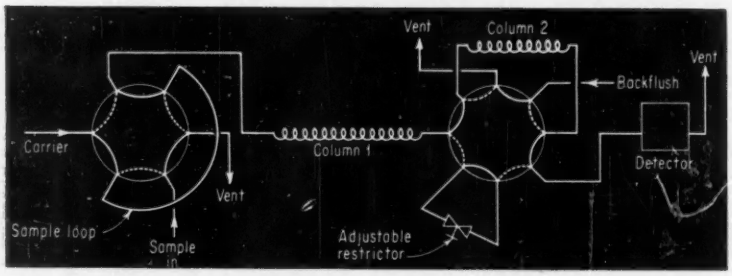

FIG. 2.

FIG. 1 shows the six-port valve employed in the combination of a first column which is permanent in the system and the second column which is stored. The first-column effluent is permitted to flow either through the second column or through a balancing flow restrictor to the detector. The restrictor, essential to the maintenance of analyzer stability, is adjusted at the operating temperature to give the same pressure drop as the second column, so that when the second column is cut out of the system, the carrier flow rate through the detector remains unchanged. FIG. 2 shows essentially the same arrangement except for backflushing the second column. Here, an eight-port valve is required so that the special backflushing stream can be introduced into the column. The flow balancing restrictor is the same as used for column storing. It is essential that switching valves do not leak. Even minor leaks lead to instability of base line, lack of analytical precision, and spurious chromatographic peaks.

port valves which simply routed the carrier gas flow either through the column or through the flow balancing restrictor. The downstream ends of the column and the restrictor were connected. This proved to be unsatisfactory. Since only one end of the stored column was sealed, leaving the other end exposed to the flowing carrier stream, sample components tended to diffuse up into the lower end of the stored column, thus giving rise to spurious peaks and exposing the column material to possible damage. Hence the development of the six-port valves, Figure 1, and the eight-port valves, Figure 2, which seal off both ends of the column.

Multiple column gas chromatographs are now commercially available. Those analyzers stemming from the Union Carbide design usually employ lineal valves to effect both column switching and sample introduction. One maker has standardized on six-port lineal valves for all functions. For backflushing, two such valves are used with two ports of one valve sealed, yielding essentially the same action as a single eight-port valve. Most manufacturers operate the sample and column-switching valves independently of each other. However, one maker employs a 16-port valve to introduce the sample and permit the flushing of one column.

Typical Applications of Multiple Column Chromatographic Systems

Multiple column systems can be arranged in a large number of combinations. There is no basic reason for not employing systems of four or five columns except for the additional complexity due to setting up and balancing the various flows, tailoring the column lengths for optimum operation, the increased possibility of leaks and mechanical failures, and the increased analyzer instability. Even limiting the discussion to four-column systems prohibits a detailed discussion of applications and relative merits of the possible combinations. Therefore the following section details only several widely used multiple column systems. While it is certainly feasible to devise a system that incorporates a backflushed column together with a stored column, the two techniques are discussed separately.

Column storing improves total-sample analysis

A good example of the column storing technique is the total analysis of a stream containing oxygen, nitrogen, methane, and carbon dioxide. A Linde 5A molecular sieve is widely used as a column packing material for the separation of oxygen, nitrogen, and methane. It is, however, damaged by carbon dioxide. The analysis can be effected easily by using a dual column system with the molecular sieve column in the second position and stored. The first column packing material must hold the carbon dioxide longer than the rest of the sample. Figure 3 shows the appropriate arrangement for analyzing this sample. The oxygen, nitrogen, and methane pass through the first column and into the second one, at which time the second column is switched out of the system and stored. Then the carbon dioxide is eluted from the first column and detected. As soon as the first column is swept clean, the second column may be cut back into the system and the oxygen, nitrogen, and methane eluted and detected.

Another example of column storing, Figure 4, employs a permanent column in conjunction with

two separate, stored columns such as for the total analysis of a sample containing oxygen, nitrogen, methane, ethane, ethylene, and butadiene. The system would be set up with the first column a permanent one containing a low molecular weight polyethylene packing; the second column, a stored column of silica gel; and the third column, a stored column of molecular sieve. System operation involves permitting the oxygen, nitrogen, and methane to pass through the first and second columns and enter the third column. The third column is stored, and at the same time ethane and ethylene would be permitted to pass the first column and into the second column. The second column is also stored. As soon as the butadiene is eluted from the first column, the second column may be cut back into the system and the ethane and ethylene eluted and detected. The third column may then be switched.

Setting up such a system requires close tailoring of column lengths and precise valve timing sequences.

Column flushing speeds key component analysis

To demonstrate various combinations of the column backflushing technique, a hypothetical process stream containing ethylene, ethane, propane, normal butane, and butadiene will be considered. This variety shows how to meet several different analytical needs that one might encounter in different production units for control of a process.

Required: Fast analysis of ethane and ethylene—Heavier materials are of no interest. Silica gel can separate ethane and ethylene, but the elution time of propane, normal butane, and butadiene from such a column is prohibitively long. Such requirements can be met using a dual column system: the first being a gas-liquid partitioning column such as Octoil-S on firebrick and the second column being silica gel for ethylene-ethane separation. Figure 5, page 81, shows the analysis and column switching sequence. Triangles indicate components of interest. The first column passes unseparated ethane and ethylene rapidly into the second column. Then the first column containing unseparated propane, butane, and butadiene is cut out of the system and backflushed to vent. The ethane and ethylene next pass through the second column and are detected separately. This particular analysis can be done in 2 min, whereas at least 15 min would be required if a single silica gel column were employed.

Total Analysis Using Column Storing

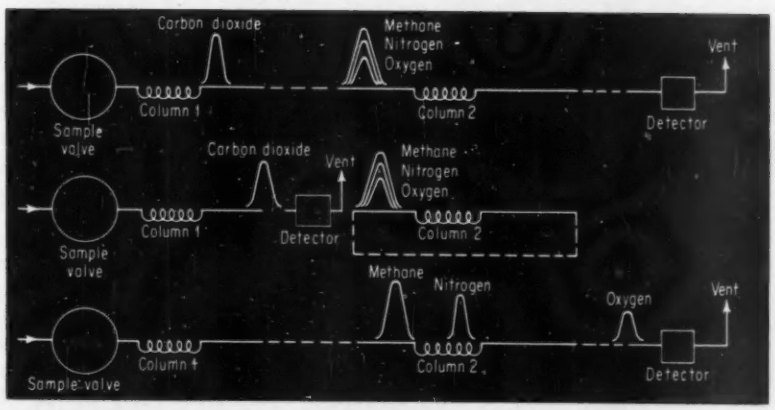

FIG. 3
One stored column.

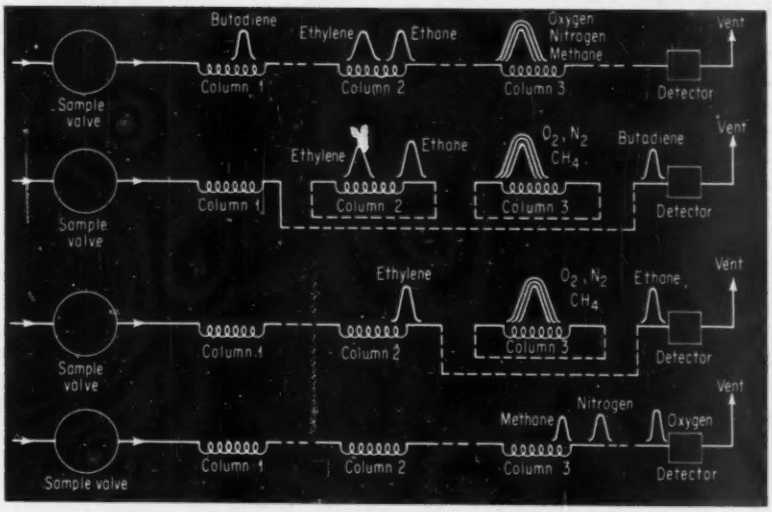

FIG. 4
Two stored columns.

Required: Fast analysis of ethane and butadiene—For this application the same columns would be employed as above except that the second (silica gel) column will be backflushed rather than the first (Octoil-S) column. The analysis and sequence is shown in Figure 6. Both columns remain in the system until the ethane elutes from the second column and is detected. Then the second column is cut out and backflushed while the detector sees the butadiene eluting from the first column. The first column must be tailored so that the butadiene is close to the end of the column when ethane is detected from the second column. This analysis can be performed in 2½ min.

Required: Fast analysis of ethane and normal butane.—Here a practical system would be a triple column instrument, Figure 7. The first and second columns could be composed of Octoil-S on chromosorb, the third of silica gel. The columns must be so tailored that during the time ethane is detected from the third column, normal butane is at the downstream end of the second column. The third column is cut out to backflush ethylene and propane through the vent, and the second column is connected to detect butane. The butadiene is caught in the first column and backflushed to vent. Obviously this arrangement will require some careful tailoring of column lengths and balancing of flows. The system is not, however, prohibitively difficult to set up. It should be pointed out that if the column backflushing valves are actuated independently of each other, the first column may be switched out of the system and backflushed whenever normal butane has been passed from it. This is very desirable since it allows more freedom in tailoring column lengths.

Trace analysis by backflushing

An interesting application of multiple column chromatography using backflushing techniques is for trace analysis of a sample minor component which is poorly resolved from a major one. Here, the technique differs depending on whether the trace component elutes *before* or *after* the major component.

Traces of ethane in a preponderance of ethylene are very difficult to analyze owing to the problems of separating the two components. Silica gel will elute ethane *before* ethylene and do so readily when the ethylene-to-ethane ratio is as small as 10 to 1. However, often encountered is the need for separating ethane from ethylene when the ratio is 1,000 to 1 or more. A dual column system, both columns using silica gel packing and with the first column to be backflushed, can be set up so that the first column will not quite separate ethane from ethylene but will concentrate the ethane in the leading edge of the sample wave. As soon as this leading edge has passed into the second column, the first column may then be cut out of the system and backflushed to discard the bulk of the ethylene. This then permits the second column to separate a sample having a far more favorable components ratio. Here again the time sequence is quite critical. If the first column is cut out too soon, some ethane is lost and a poor, inaccurate analysis will result. If the first column is cut out late, however, too much ethylene will be sent to the second column with the resulting difficulty of separation.

When a poorly separated trace component elutes *after* the major component, the analysis is more difficult but can still be accomplished. A double column system is employed, but only the first column is in the system when the sample is introduced. This column achieves a partial separation of the major component from the minor component. As soon as the bulk of the major component has been eluted and vented, the column is reverse-flushed, thereby grouping the minor component with a portion of the major component back in the first column. At the same time a second column is placed between the first column and the detector. On restoring normal-direction carrier gas flow, the improved sample in the first column enters the second column for analysis. The net result is the same as charging a sample of much more favorable components ratio to a single column instrument.

Benefits and pitfalls

Many advantages accrue from using multiple columns in gas chromatography. Not only do they allow more rapid analyses than are possible with a single column instrument, but they also permit using different columns for different portions of the sample. Thus column development requirements are reduced since it no longer becomes necessary to develop an optimum single column.

There are certain disadvantages, however. Sometimes, but not often, satisfactory stability requires a zero balance prior to reading each peak of interest or—if conditions are bad enough—after each positioning of the various valves.

Programming of multiple column systems is often fairly complicated and must be handled carefully since the timing sequence usually must be quite exact. Those persons who set up and maintain such analyzers need a considerably greater understanding of instrument operation and the function of each column than is required for single column analyzer personnel. One serious problem many have encountered using multiple column systems, particularly the column storing techniques, have been leaks. Very tiny leaks in fittings to the valve or within the valve itself cause analytical imprecision, spurious and unexplained peaks, and instability of base line. Leaks make balancing of flows difficult or impossible. Furthermore, they give rise to conditions where components elute faster through the column in one valve position than another, making programming virtually impossible.

In recent years there has been considerable development in the direction of miniature or small

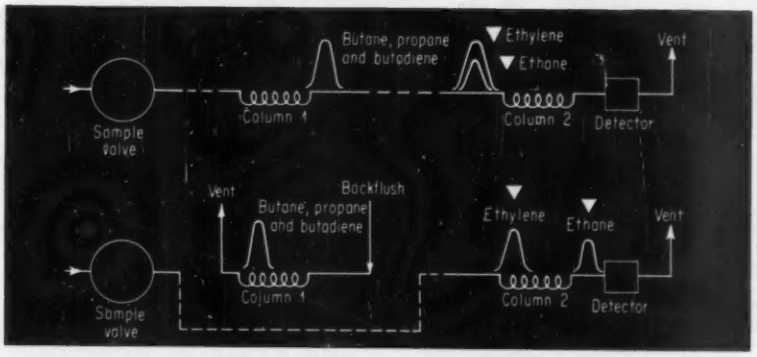

FIG. 5
Fast analysis of ethane and ethylene by first column backflush.

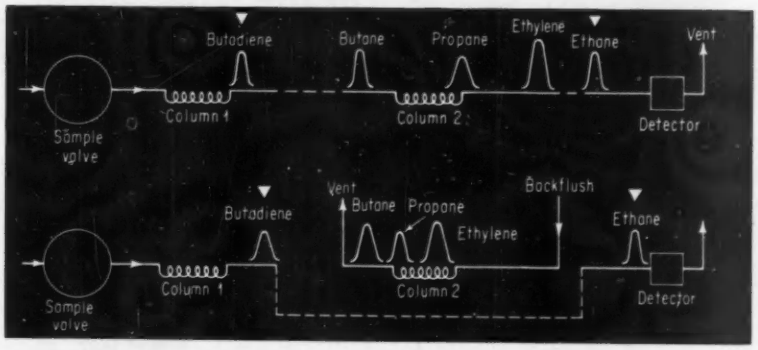

FIG. 6.
Fast analysis of ethane and butadiene by second column backflush.

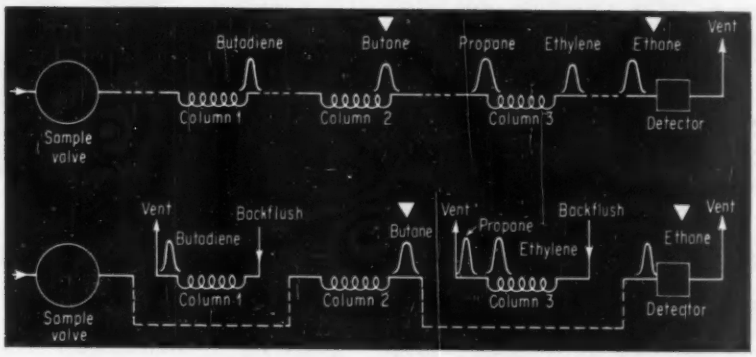

FIG. 7.
Fast analysis of ethane and normal butane by two-column backflush.

samples with ⅛-in. packed columns which give analyses much more rapidly than their ¼-in. counterparts. Total analyses of C_4's, for example, have been accomplished in 1 to 1.5 min. However, multiple columns are occasionally used even with faster columns to cut down analytical time still more or to protect certain columns from a damaging sample component. Multiple column techniques are expected to continue to be a major factor in process chromatography.

Using multiple columns in gas chromatographs for process control in no way modifies the problems of process control other than to provide an analysis in a shorter time, making it possible to actually use a gas chromatograph on process control in some applications where the analytical time with a single column chromatograph would have been excessive. The hardware for utilizing the intermittent signal of a chromatograph and converting it to the necessary pneumatic or electrical signals for process control has been available for some time. Applying a multiple column chromatograph is simply a matter of building up the necessary hardware and working out the details of the process loop.

REFERENCE

CHROMATOGRAPHY ANALYZES GAS AND VAPOR PRODUCTS IN THE PLANT, C. G. Fellows, "Control Engineering", July 1957, pp. 75-81.

Now...new from Bailey

...a "foolproof"

FLAME DETECTOR

that rejects flames from other burners

Flame detectors are sometimes "fooled" by glowing refractories or flames from burners adjacent to that under surveillance. This new Bailey Flame Detector *responds only to the flame it surveys* . . . assures positive monitoring of coal, gas, oil or combination fuel-fired furnaces. Absence or failure of flame is sensed and accurately signaled—or relayed to control auxiliaries—without use of external relays or amplifiers.

Here are other distinctive features that make this new Bailey Flame Detector outstanding:

Wide temperature range . . . is suitable for use in areas with ambient temperatures from -20 to +300° F. Flame sensing element withstands temperatures up to 600° F.

Easy inspection . . . quick disconnect, keyhole mounting simplifies checking of lens condition and detector alignment.

Simple, solid-state circuitry . . . Bailey Flame Detector unit contains only 8 components.

Weatherproof construction . . . design of Bailey unit makes it suitable for outdoor installation.

Why not have your Bailey Engineer give you more information? Call the Bailey district office, or write us.

A147-1

Instruments and controls for power and process

BAILEY METER COMPANY

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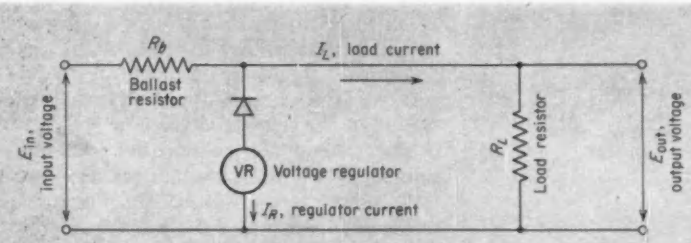
In Canada—Bailey Meter Company Limited, Montreal



Application of a semiconductor voltage regulator is based upon the operation of the elementary shunt regulator shown here.

Simplified Guide Aids Selection of Semiconductor Voltage Regulators

Solid state voltage regulators are available in a wide range of voltage ratings. No longer must the engineer compromise the design of a regulated circuit to accommodate a limited range of voltage regulator ratings. He may now choose the voltage regulator to fit the regulated circuit. Low cost and abundant variety have opened application to surge protectors, ac regulators, reference voltage circuits, clipping circuits, and dc coupling and biasing circuits. The selection method given here handles such applications.

LARRY BLOOM, Semiconductor Div. General Instrument Corp.

Must Know:

- E_{in}, the input voltage, and its variations, $E_{in(max)}$ and $E_{in(min)}$
- I_L, the current supplied to the load, and its variations, $I_{L(max)}$ and $I_{L(min)}$, due to changes in load resistance, R_L
- E_{out}, the output voltage to the load

To Determine:

- That E_{out} is less than $E_{in(min)}$
- $I_{R(max)}$, maximum current through the regulator for worst combination of circuit conditions.

$$I_{R\,(max)} = \frac{(E_{in\,(max)} - E_{out})\,(I_{L\,(max)} + K)}{(E_{in\,(min)} - E_{out})} - I_{L\,(min)} \qquad (1)$$

where $K = 0.1\,I_{L\,(max)}$, a 10-percent safety margin.

- P_{VR}, maximum power dissipation for the most extreme circuit condition. This determines the capacity of the regulator needed. With it, enter

the chart below and select a regulator having at least an equal power rating.

$$P_{VR} = I_{R\,(max)}\, E_{out} \tag{2}$$

• $R_b = \dfrac{E_{in\,(min)} - E_{out}}{I_{L\,(max)} + K}$, ballast resistance (3)

• $P_{Rb} = (I_{R\,(max)} + I_{L\,(max)})^2\, R_b$, power rating of ballast resistor (4)

Example

$E_{in\,(max)} = 22$ volts; $E_{in\,(min)} = 20$ volts

$I_{L\,(max)} = 0.50$ amp; $I_{L\,(min)} = 0.40$ amp

$E_{out} = 12$ volts

Then

$$I_{R\,(max)} = \frac{(22 - 12)(0.50 + 0.05)}{(20 - 12)} - 0.40 = 0.49 \text{ amp} \tag{1'}$$

and $P_{VR} = (0.49)\,(12) = 5.88$ watts (2')

On the chart find the voltage (12 volts) closest to the output voltage, in the column designated "Nominal Regulator Voltage". In the row marked "Regulator Current" locate the current closest to the calculated value of $I_{R(max)}$. At the intersection of the column and the row is the number, 1N1353, of the correct regulator type—if its power rating is adequate. It is, since the rating is 10 watts and the calculated power dissipation is 5.88 watts.

Finally,

$$R_b = \frac{(20 - 12)}{(0..0 + 0.05)} = 14.5 \text{ ohms} \tag{3'}$$

$$P_{Rb} = (0.49 + 0.50)^2\, 14.5 = 14.2 \text{ watts} \tag{4'}$$

REGULATOR CURRENT, MILLIAMPERES

Nominal regulator voltage, volts	0.20 to 1.0	1.0 to 5.0	0.20 to 1.0	1.0 to 5.0	1.0 to 5.0	10.0 to 12.0	20.0	5.0 to 10.0	12.0 to 35.0	5.0 to 25.0	30.0 to 100.0	25.0 to 150.0	50.0 to 150.0	500.0 to 1000.0	65.0 to 280.0	290.0 to 2000.0
2.5				1N 465	1N702											
3.5				1N1927	1N703		1N747		1N1507		1N1518	1N1588				
4.5		1N1982		1N 468	1N705	1N761	1N750	1N2032	1N1508		1N1519	1N1589		1N2041		
5.5		1N1983		1N1929	1N706	1N762	1N752	1N2033	1N1509		1N1520	1N1590		1N2042		
6.5		1N1984		1N 470	1N707	1N763	1N754	1N2034	1N1510		1N1767	1N1591		1N1805		1N2804
8.0		1N1985		1N1931	1N764	1N713	1N756	1N2035	1N1511	1N1522	1N1769	1N1592		1N1807		1N2806
10.0		1N1986		1N1932	1N765	1N714	1N758	1N2036	1N1512	1N1523	1N1771	1N1593		1N1351		1N2808
12.0		1N1987	1N1933		1N766	1N716	1N759	1N2037	1N1513	1N1524	1N1773	1N1594		1N1353		1N2810
14.5	1N1988		1N1934		1N767	1N718		1N1514		1N1525	1N1775	1N1595		1N1355		1N2812
18.0	1N1989		1N1935		1N768	1N720		1N1515		1N1879	1N1777	1N1596	1N1357			1N2816
22.0	1N1990		1N1936		1N769			1N1516		1N1779		1N1597	1N1359			1N2819
27.0	1N1991		1N1937		1N724			1N1517		1N1781		1N1598	1N1361			1N2822
33.0	1N1992		1N1938		1N726					1N1783			1N1363			1N2824
40.0	1N1993		1N1939		1N728					1N1785			1N1365			1N2826
47.0	1N1994		1N1940		1N730					1N1787			1N1367		1N2829	
56.0	1N1995		1N1941		1N732					1N1789			1N1369		1N2832	
68.0	1N1996		1N1942		1N734					1N1791			1N1371		1N2834	
75.0					1N735					1N1792			1N1372		1N2835	
80.0	1N1997		1N1943		1N736					1N1793			1N1373		1N2836	
100.0	1N1998		1N1944		1N738					1N1795			1N1375		1N2838	
120.0	1N1327				1N740					1N1797			1N1810		1N2841	
150.0					1N742					1N1799			1N1812		1N2843	
180.0					1N744					1N1801			1N1814		1N2845	
200.0					1N745					1N1802			1N1815		1N2846	
Power rating, watts	0.150		0.200		0.250		0.400	0.750		1.00		3.50	10.0		50.0	

Incremental Servos

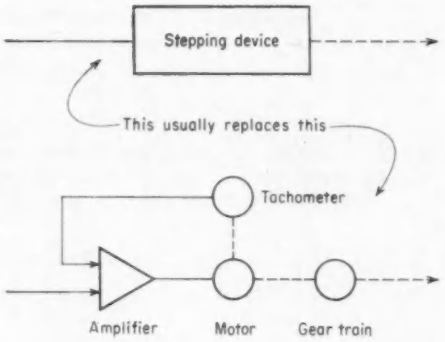
Part III— How They've Been Used

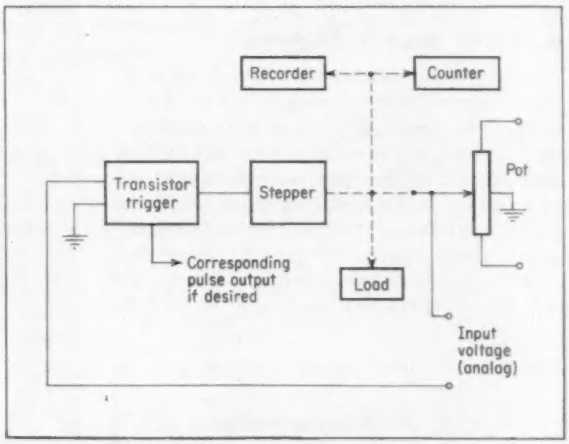
THE GIST: In preceding articles, author Bailey has compared the incremental servo with its stepless predecessor, described its two principal design configurations, and analyzed its operation to demonstrate how its resembles at times a position servo and at other times a velocity servo. To illustrate the versatility of this device, he now describes 16 specific applications—some real, some just proposed—in which the stepper serves as a key component.

S. J. BAILEY, Vitro Corp. of America

1. Stepping Servo

In this application the stepping device replaces an amplifier, a motor, a tachometer, and a gear train. The rotation rate of its output shaft is directly proportional to input pulse rate.



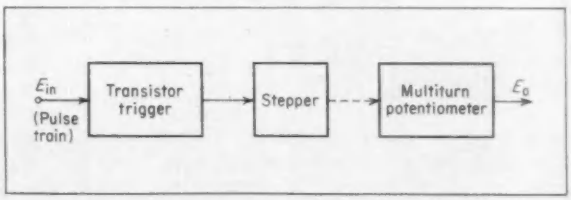


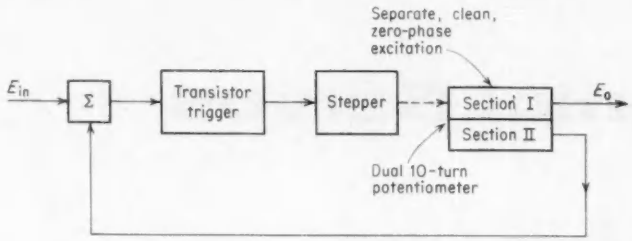
2. Proportional Control

This arrangement may be viewed as a self-balancing potentiometer, suitable for process control applications. The recorder and counter shown are optional. It is assumed here that the input voltage periodicity is considerably greater than the stepper's response time.

3. Pulse to Analog Conversion

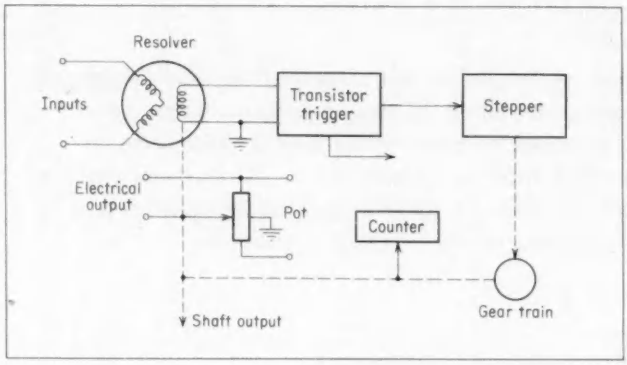
In this case the stepper increments must be small relative to the periodicity of the analog output.





4. Analog to Analog Conversion

Here the stepper acts as a filter to eliminate harmonics, noise, quadrature, and phase shift; the arrangement changes dc to ac, ac to dc.

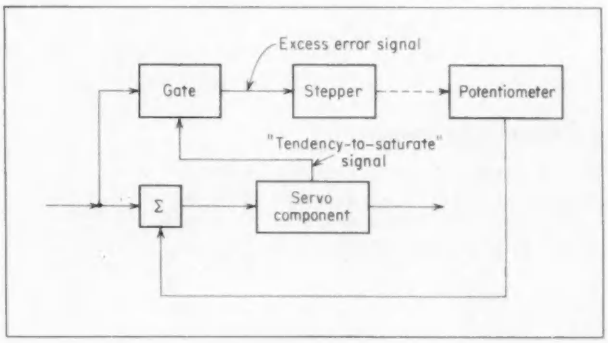


5. Vector Addition

Both electrical and mechanical solutions are offered by this arrangement, which can also serve as a function generator.

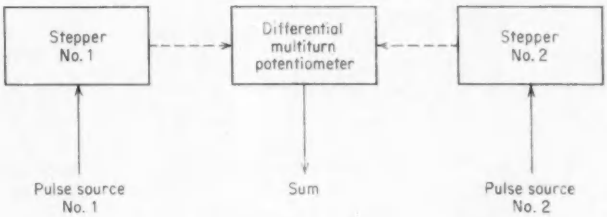
6. Error Signal Storage

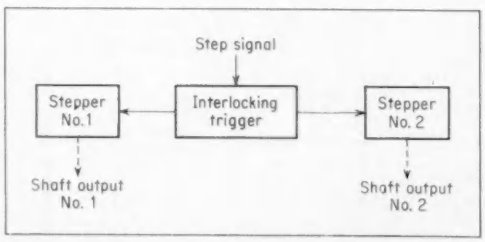
The stepper accepts saturating error signals, stores them, and resubmits them when danger of saturating critical servo components is past. It thereby improves stability. This system applies to cases where a servo component might respond poorly if saturated. In operation the "tendency-to-saturate" signal opens the gate to store the excess signal until the difference signal into the servo falls below a preselected value.



7. Algebraic Pulse Summation

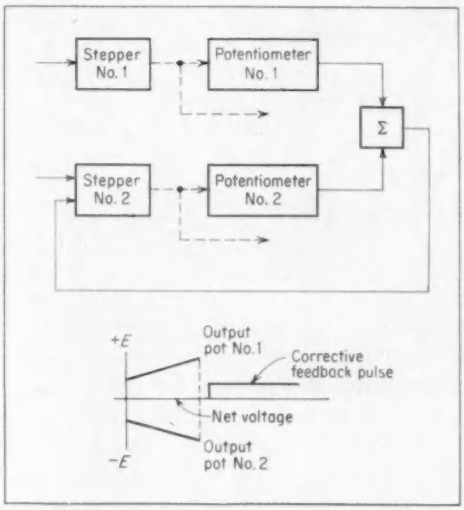
Two steppers drive a differential multiturn potentiometer to provide an analog output equivalent to the algebraic sum of the two pulse inputs.





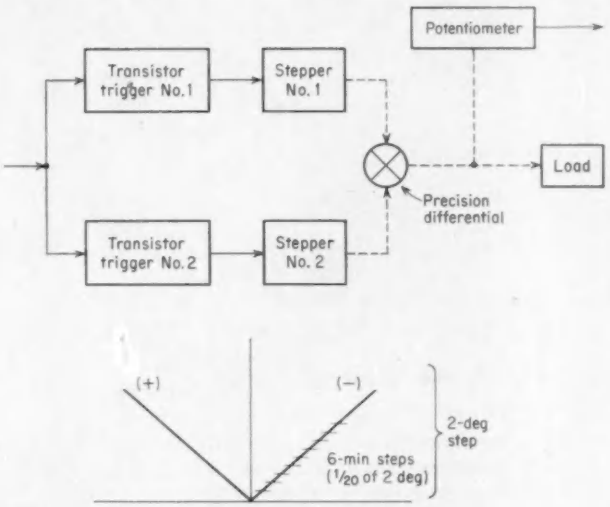
8. Remote Stepper Interlock

Linking two stepping motors with an "interlocking trigger" provides an absolute interlock of remote stepping controls. Programmed pulses applied to the trigger cause it to switch a current pulse to one of the steppers. When the stepper has completed a full unit step, it signals the interlocking trigger to pulse the other stepper, which in turn signals the completion of its step. Thus the two remote stepping programs always remain synchronized since one cannot step until the other has signalled a completed step.



9. Asynchronism Detection

Where two systems must be kept in exact step, two stepping motors can be used to detect any asynchronism. In the diagram shown any differential voltage between the two output pots causes one stepper to take an extra step, thereby restoring synchronism. In practical applications a short time delay in the feedback trigger channel allows for very slight differences in stepping time.

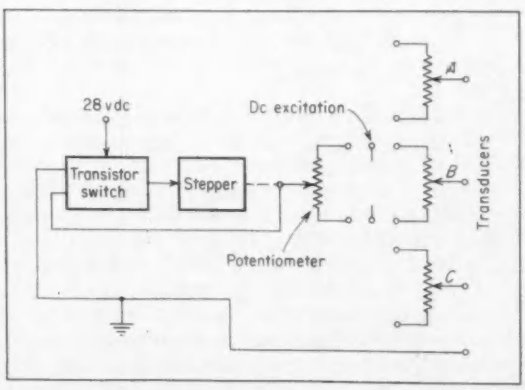


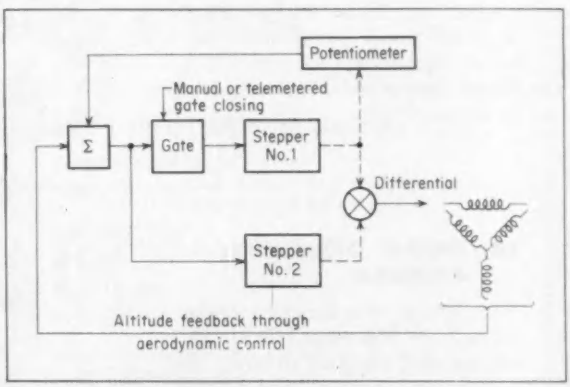
10. Improving Response Near Null

To provide ultra precise response in the vicinity of null, two stepping motors, each with a different size step, are connected to the load. The transistor triggers are biased as follows: trigger No. 2 rejects any error signal corresponding to a 2-deg (or larger) step; neither trigger responds if the input signal corresponds to a 6-min (or smaller) step. The system thus exhibits three operating phases: 1) if the error exceeds 2 deg. one motor will step in 2-deg increments; 2) if the error is less than 2 deg but greater than 6 min, both motors will step in 6-min increments; and 3) if the error is less than 6 min, the motors will not step at all.

11. Pressure Transducer Calibration

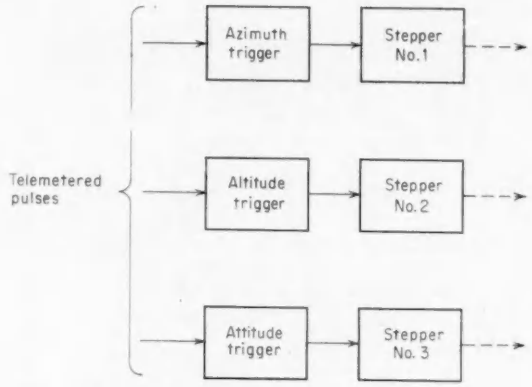
This system provides a voltage ratio readout easily visible from a distance. Pressure ranges are automatically programmed to the transducers, and accurate calibration curves can be quickly plotted. The system may be used as a multiple pressure readout.





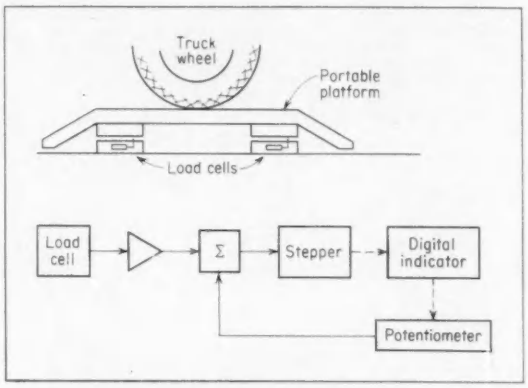
12. Altitude Hold Servo

In this system two stepping motors coupled to a differential are counter-rotated so as to produce zero output when the gate is open. The output of stepper No. 1 does however drive the potentiometer. After the gate is closed, either manually or by some telemetered signal, stepper No. 2 operates to hold the altitude represented by the potentiometer output.



13. Drone Control

In addition to their telemetered airborne guidance applications, steppers also form part of a ground system indicator which monitors drone progress in the prescribed course.

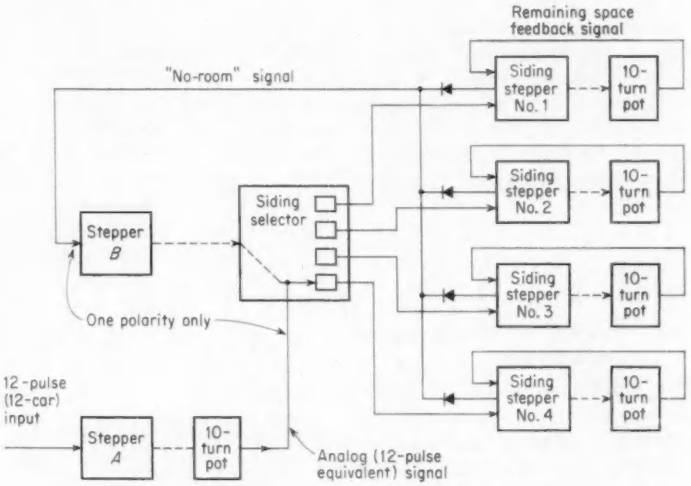


15. Portable Weighing Station

Here the stepper drives a digital indicator in a closed-loop readout device. This system is used at temporary truck weighing stations set up along highways.

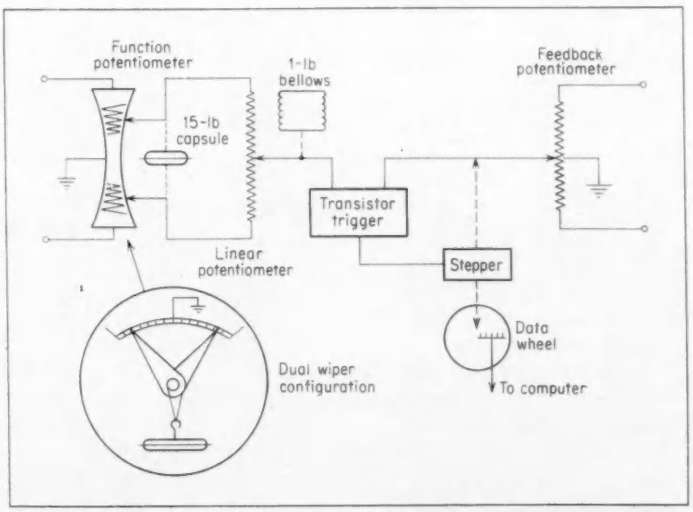
14. Railroad Car Sorting

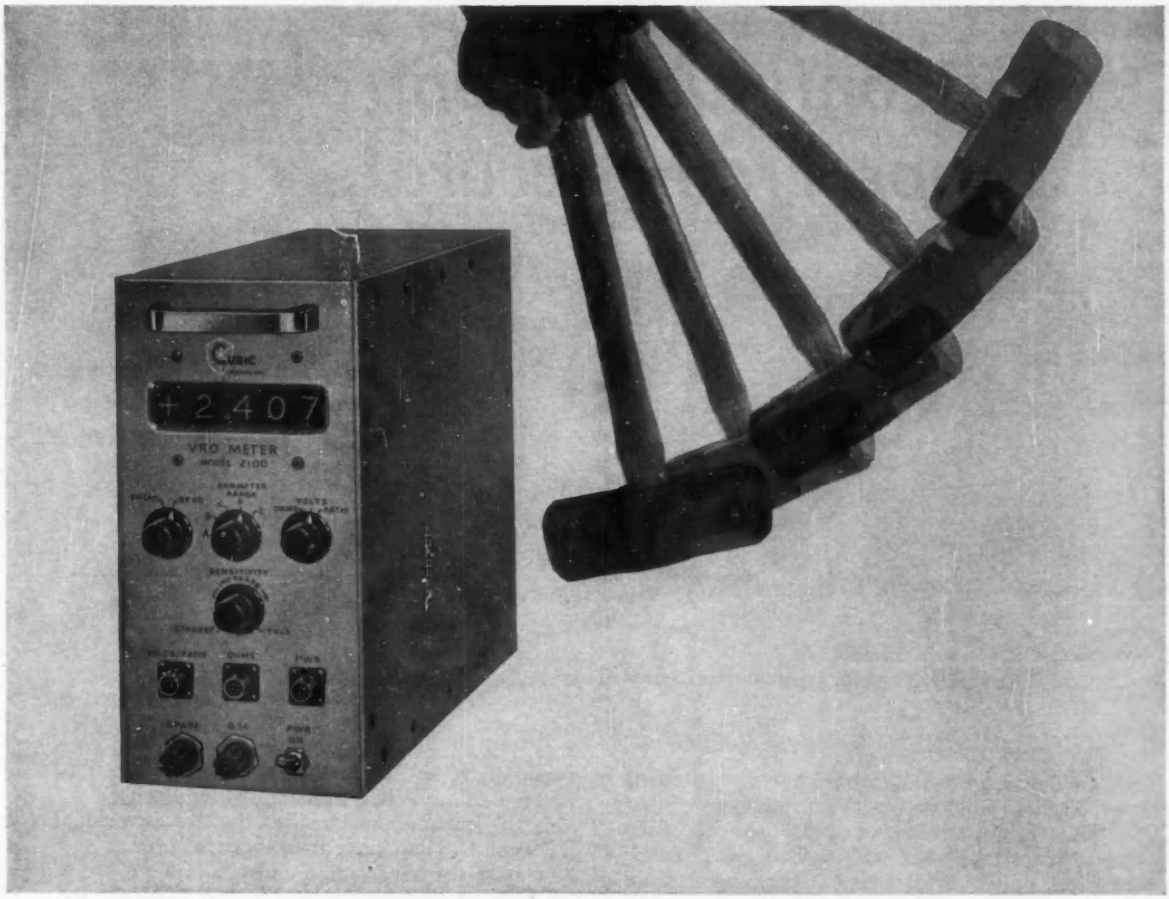
In this system each siding has a corresponding stepper output. Master steppers assist in the exploration of each siding for adequate car space. A 12-pulse signal, introduced by a 12-car string passing a track pickup, is stepped off by stepping motor A into a 10-turn pot. The corresponding analog output is compared with each siding by stepper *B*, until a siding is found which will accommodate the 12-car string. Then stepper *B* stops. Next the 12-pulse analog signal drives the appropriate siding stepper until it is balanced by feedback pot.



16. Digital Differential Altimeter

The output of a function potentiometer is determined by a pressure capsule designed to cover the entire altitude range and is used to excite a linear potentiometer. This in turn is driven by a 1-lb bellows to produce accurate readings in the neighborhood of the selected altitude. Stepper output is then put in binary form for transfer to a computer.





Cubic precision digital voltmeter withstands 50G shock

A new militarized version of the Cubic precision digital voltmeter is guaranteed to withstand shocks as high as a bone-crushing 50 G. The ability to shake off punishment that would wreck ordinary voltmeters, and to keep on performing perfectly for years and years under the hardest kind of use, is built into *every* Cubic digital voltmeter. These meters are "operator-proof"—they will not be damaged by any except the most flagrant misuse. Even voltages 100% over the top of the highest range will not harm them.

The advanced engineering of Cubic's transistor-driven stepping-switch design provides extraordinary reliability and accuracy. Cubic digital voltmeters achieve 99.997% repeatability, for precise accuracy again and again. Attenuator accuracy is 0.003% for wide-range precision. Bridge linearity of 0.003% is attained with carefully matched quality components. Noise rejection (60 cps) is 80 db.

Cubic's digital readout is simple, reliable and the easiest to read at a glance. Extra quality components throughout ensure minimum maintenance requirements. Before buying *any* digital instrument, investigate the best. *Write for descriptive literature to Dept. CT-100, Industrial Divisions, Cubic Corporation, San Diego 11, Calif.*

BRIEF SPECIFICATIONS — MODEL 2100

ENVIRONMENTAL

shock test: will withstand 50G Navy shock test, and shipboard vibration

humidity: 100%

salt spray and fungus resistant

ELECTRICAL

volts: 0.01% accuracy from 1 millivolt to 1000 volts, automatic ranging and polarity

ohms: 0.1 ohm to 10 megohms, manual ranging

input power: 25 watts

ratiometer provision and switching

MECHANICAL

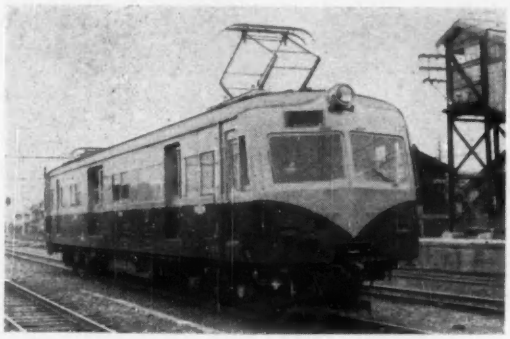
size: 5½" wide, 11¼" high, 14" deep

weight: 35 lb

cubic
CORPORATION

CIRCLE 89 ON READER SERVICE CARD 89

Discontinuous Control Stops Train Accurately



The Japanese National Railways has developed an automatic braking apparatus for rapid transit electric trains that will apply braking power to this 50-ton mail car going at 45 mph while 750 ft from the station and stop the train within 4 in. of the desired point in the station.

TOSHIHIKO ITO, Japanese National Railways

The design of a control system for automatic train braking relies on optimum nonlinear control, as shown by the phase-plane plot, Figure 1. Here the ordinate represents train velocity and the abscissa the train's displacement or running distance. The origin O is where the train should stop.

Simply, the control system principle is this. Curve *CBO* is the trajectory of motion the train will follow as it slows down under some constant braking force. When the train approaches the next station at a particular speed such as E_1 the speed curve crosses the *CBO* curve at distance B_1 ahead of the station. The control system senses that the actual train speed is greater than the desired speed at B_1 and applies full brake force to the train so that ideally the train will slow down along trajectory B_1O.

However, in practice a constant brake force is difficult to maintain. Actually the car slows down somewhere in between dotted curves B_1G and B_1H. Therefore the car may miss the objective point by a distance *GO* ahead of the target or *OH* after. To minimize final error, this concept of on-off nonlinear control of braking force is retained but instead the control system reduces the braking force step-by-step in much the same manner as a human operator so that near the objective point the reduced braking force, even though not constant, contributes only a negligible displacement error at the station stop.

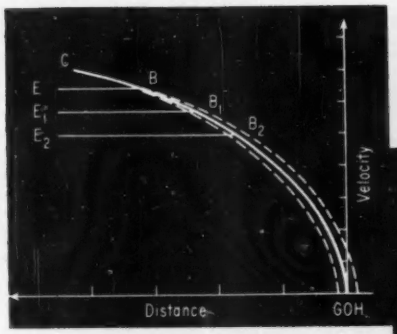
Applying the principle

Two approaches have been taken to implement piecewise optimum nonlinear control of electric train operation. The first method employed is described by Figure 2. (While not adopted for the final system, the initial approach aided the development of the second.) Here, three trajectories are used. Curve *CD* represents train motion under full ordinary braking force, *IJ* represents about one-half braking force, and *RO* about one-quarter braking force. The three trajectories are actually set up on function generators in the controls, the generators becoming operative at distances C', I', and R' ahead of the station.

When the train, running at a speed corresponding to point *E*, approaches the station, its speed is less than any speed established by the train motion trajectory *CBO*. At the intersection of the actual and desired speeds, point *B*, the control system senses that braking action is needed to slow down the train and applies full braking force. Assuming the car can respond instantaneously the train motion will follow along curve *BD*, and hence there will be some large error equal roughly to distance *DO*. However, at point I' the second trajectory is switched in and when the actual trajectory intersects the new desired trajectory at point *P*, the control system senses that the car is slowing down too fast. Hence, the system weakens braking power to about one-half normal and ideally the train will stop at point *J*. But the error will still be too large. At R' the next function generator, equivalent to curve *RO*, is switched in and at point *Q* braking force reduces again. Then the train coasts in close to the final objective, point *O*. Consecutive brake weakening reduces final error resulting from an inconstant brake force.

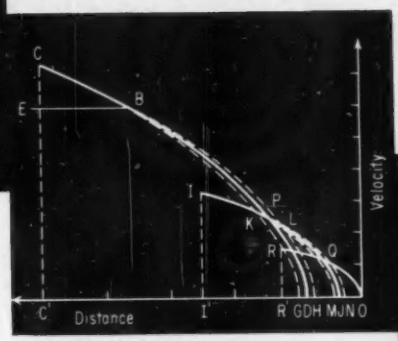
Equipment was built along the lines described

FIG. 1. Principle of nonlinear control, using phase-plane representation.



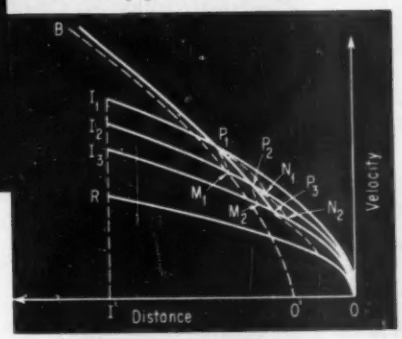
BASIC APPROACH

FIG. 2. Phase-plane trajectories for the first control method tried.



FIRST TRY

FIG. 3. Trajectories for the second control approach. The corresponding control system appears quite successful and its equipment is described here.



LATEST SYSTEM

above and actual tests run on a mail car. Results showed the final error at the objective point to be between plus and minus 3 meters, with fairly good riding comfort. For more accurate control and for improved comfort, more braking steps would be required. But each braking step calls for a separate function generator and a separate distance-from-station detector. Thus the apparatus would be large and expensive. For these reasons and also because the test car was refitted with a Westinghouse SMEE brake offering more braking steps and electrodynamic retardation, the foregoing line of investigation was abandoned in favor of the approach described next.

A family of parabolic trajectories was established for the new brake control system, Figure 3. For these curves only one potentiometric function generator is needed, with the desired trajectory determined by the voltage applied across the potentiometer. Each trajectory represents a particular fraction of the ordinary full brake force, the brake action getting weaker in steps as the actual train trajectory crosses sequentially from I_1O through to RO. To assure that the actual trajectory progresses through I_1O and so forth to RO, the brake force at each step is somewhat larger than that determined by the ideal trajectories. That is, the train is made to slow down a little faster than the optimum trajectories call for.

Briefly, here is what the control system accomplishes. At first the car slows down under full braking along the BO' curve. At distance I' the function generators become active. As shown in Figure 3, the train trajectory crosses the I_1O curve at P_1. This causes the brake force to weaken a little and the train's path is somewhere between P_1M_1 and P_1N_1. Next the train trajectory crosses curve I_2O at P_2 and the brake force weakens again. The operation continues like this from trajectory to trajectory until finally curve RO is reached. Here the reduced brake force corresponds exactly to that needed for the train to coast into the objective point O.

Brake control apparatus

Figure 4 represents the automatic braking system devised to carry out the optimum nonlinear control of an electric railway train. The control signal receiver, left, detects when the train reaches a prescribed point ahead of the next station. Such a device, called **Identra,** is widely used for railway signal control. As shown in Figure 5, part of this device is located on the track and part on the train. As the train passes over the LC coil in the track, a 100-kc signal is generated in the car portion of the **Identra** and trips a relay. Coils are placed on the test track about 240 meters (point C') and 100 meters (point I') ahead of the station.

Operation of the **Identra** relay initiates action of the distance detector and function generator. A generator on the car axle delivers pulses proportional to traversed distance, and the pulses—after scale-down by an electronic pulse divider—drive a stepping motor. Thus the stepping motor shaft position corresponds to the car distance from the station. The shaft is geared down and coupled to the function generating potentiometer, Figure 6. With a given voltage across the potentiometer, the individual resistances are adjusted such that as the po-

THE TRAIN CONTROL SYSTEM HARDWARE

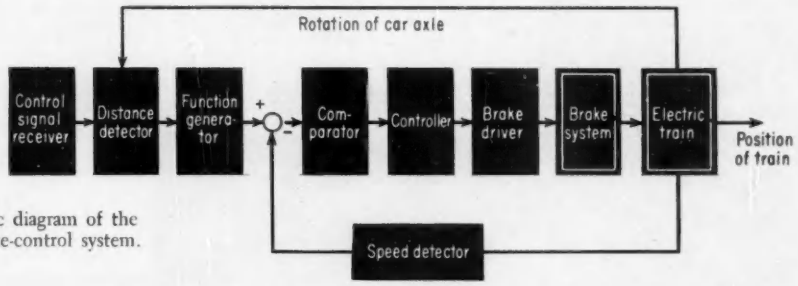


FIG. 4. Basic diagram of the nonlinear brake-control system.

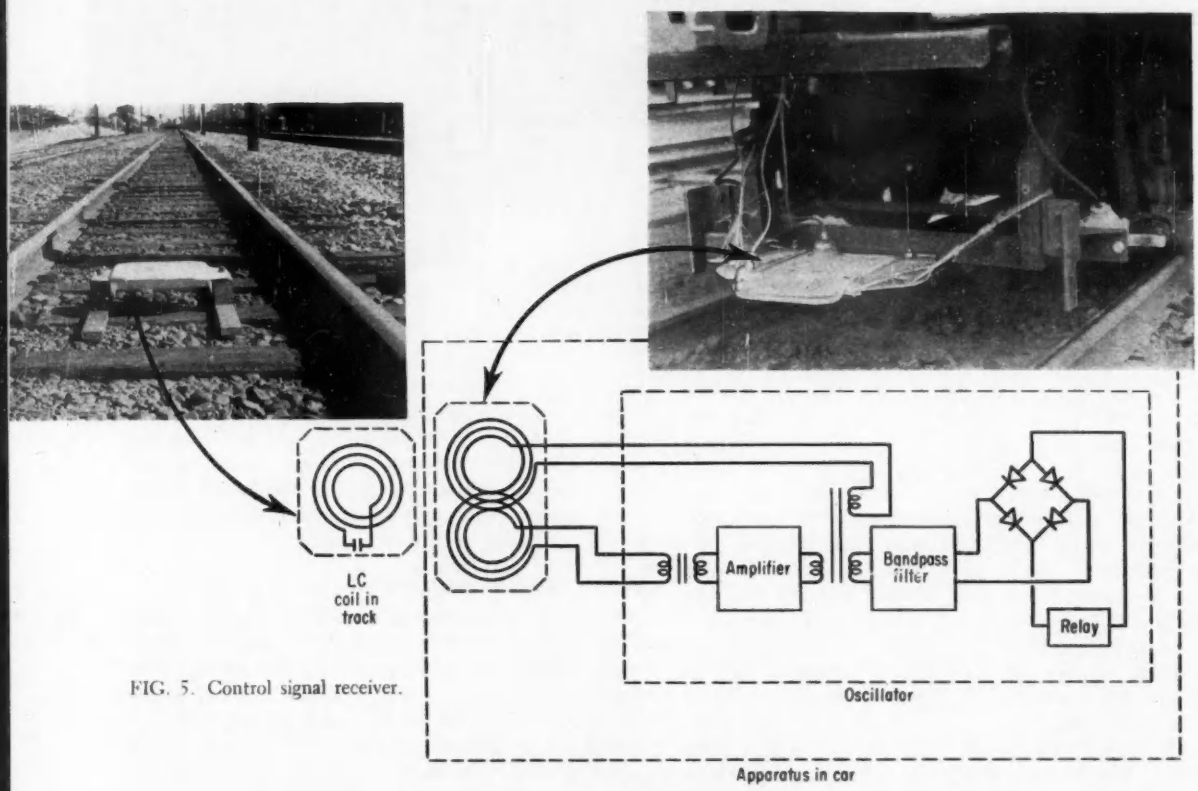


FIG. 5. Control signal receiver.

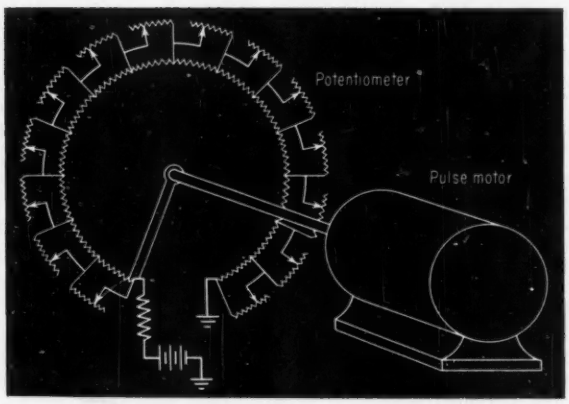


FIG. 6. The trajectory function generator is positioned by a stepping motor according to the car's traversed distance.

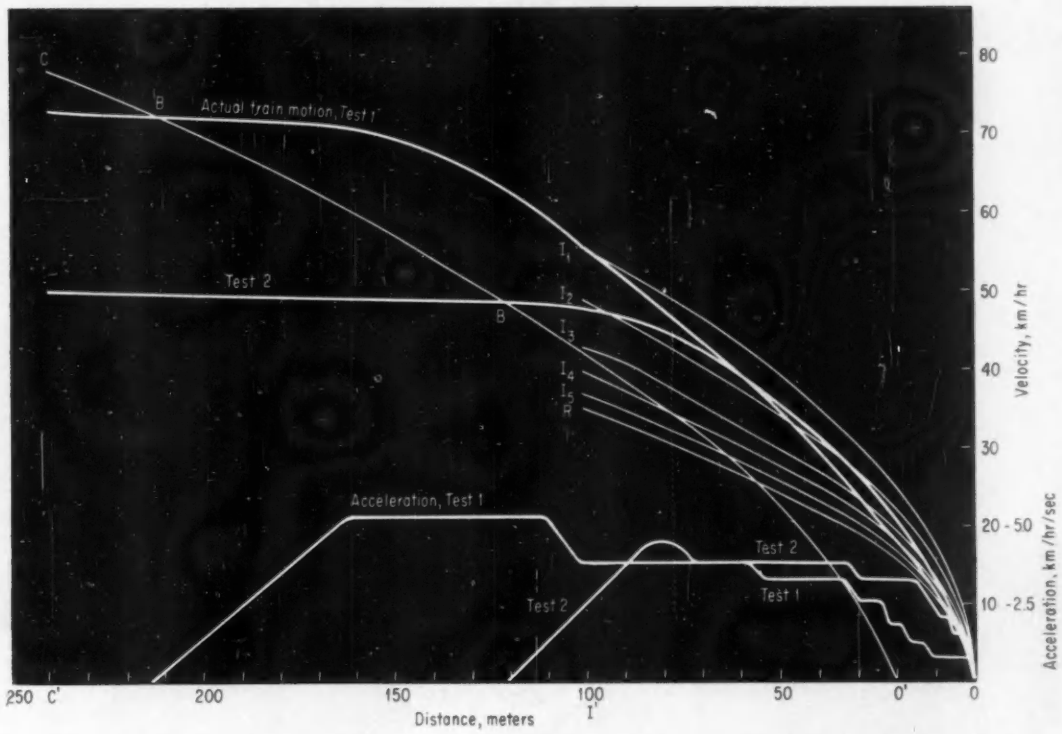


FIG. 7. Results of two test runs which the train passes the first Identra at different initial speeds. While not apparent from these records in each case the train stopped within 4 in. of the objective point.

tentiometer wiper arm—driven by the stepping motor shaft—rotates from one end to the other, the device generates a voltage curve equivalent to the desired braking trajectory.

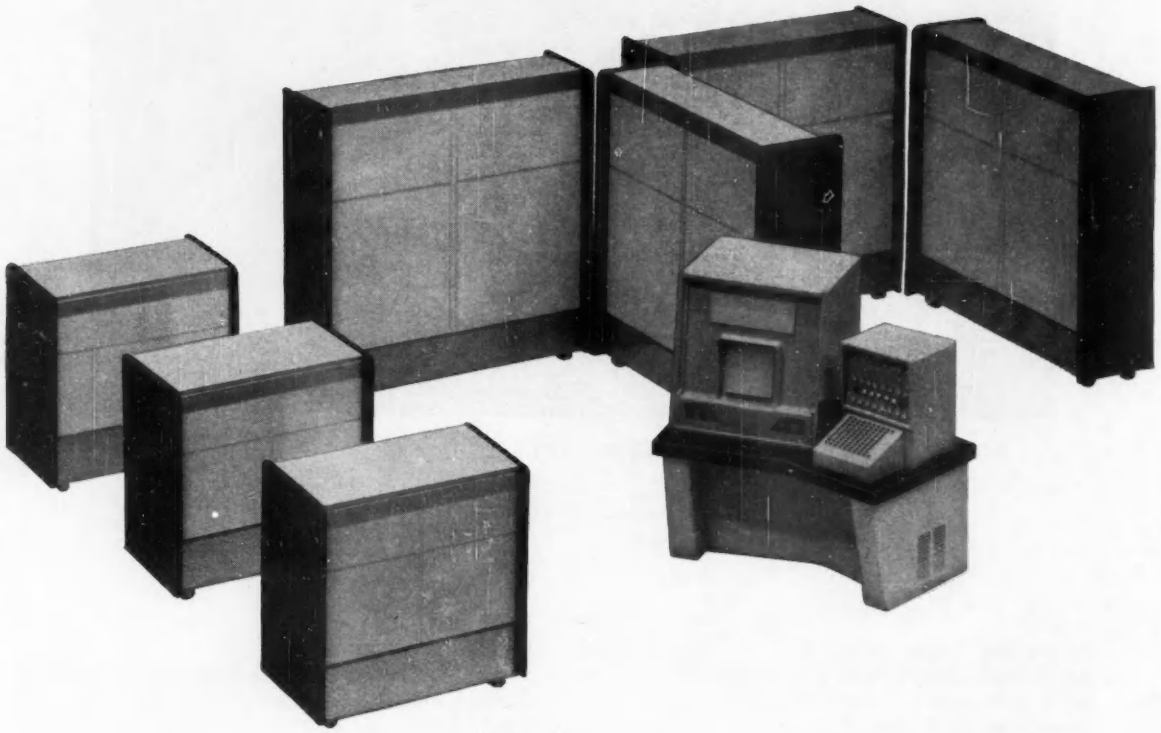
Actual train speed voltage comes from a dc tachometer generator (speed detector in Figure 4) coupled to the car axle. To effect sequential brake weakening, the actual car speed must be compared with the desired speed established by the shaft position of the function generator. The comparator, a dc differential amplifier, determines which of the two speed voltages is greater. When the actual-speed voltage becomes less than the voltage from the trajectory being generated, relay contacts in the comparator energize the controller. The controller notches to a new position, thus adjusting the brake system to a reduced brake force. Simultaneously, the comparator also reduces the voltage across the function generator, thereby setting up a new trajectory, for instance switching from I_1O to I_2O. For a while the car speed again is greater than desired, the brake force remains constant but reduced, and eventually the train trajectory crosses the new generated trajectory (I_2O) and the brake force weakens some more.

Results of train runs

Test runs of the automatic braking system on an ordinary mail or baggage car 20 meters long and weighing 50 tons were carried out on the Tokaido line on a straight level stretch about 50 kilometers west of Tokyo. When the "GO" switch is operated the train starts automatically, and its speed increases to about 75 km/hr. At a suitable point the train motor is deenergized and the train begins to coast. On passing over the first **Identra**, about 240 meters ahead of the station, the automatic braking system goes into operation and stops the train within plus or minus 10 cm of the desired spot.

Figure 7 shows results of two test runs. The heavy curves at the top of each test plot represent the train's actual trajectory, and the lower heavy lines represent the train's acceleration. Note how the acceleration increases when the trajectories cross at *B* and full brake force is applied and how the acceleration drops as subsequent crossings of the trajectories weakens the brake force stepwise. While not apparent from the test records, the displacement error at the stop was within plus or minus 4 in. Investigation is continuing for improving the braking system still further.

LFE's new RD-900 system--



. . . provides a random access file of up to 495 million bits with access to information in less than 3/10 of a second.

. . . may be operated with all standard general purpose digital computers, or as an independent storage, access and display system.

The RD-900 Random Access Storage and Display System, consists of from 1 to 33 high density, magnetic, file drums, each with a storage capacity of 15 million bits. A Symbol Generator converts coded characters into a visual message as fast as they are read from the file. One Symbol Generator is used to drive any number of output display devices. These include 21″ console displays and large screen projection displays . . . each capable of displaying up to 12,800 characters, symbols or a composite of both. In addition to alphanumeric characters the system can display arbitrary or abstract symbols, schematic or logical drawings, graphs, charts, and maps. Applications include military and industrial systems where information retrieval and display must be simultaneous for instant decision making. For a complete description and specifications write Dept. 101.

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Predicting Performance of Metering Pumps

Metering and proportioning pumps move fluids. More significantly, perhaps, they can be relied on as flowmeters because of the direct relationship between pump speed and discharge flow rate. However, pumps must be selected for a given service, pumps wear with usage, and often a new pump size must be determined for a scaled-up process. Author Beerbower derives a figure of merit for metering pumps and shows how he used it in predicting pump performance when going from pilot plant to full scale operation.

A. BEERBOWER
Esso Research and Engineering Co.

Small rotary pumps are widely used for metering and proportioning service in both pilot plant and full scale operations. But even the best of such positive displacement units suffers from some slippage (loss of discharge flow) under conditions of high pressure and low viscosity. The resulting reduced efficiency can be easily taken into account when it is recognized that the amount of slippage obeys relatively simple rules that permit calculation—from two measurements—of pump efficiency for almost any conditions of service.

Two basic factors, the differential pressure across the pump and the fluid viscosity, influence the amount of slippage. Pump manufacturers frequently provide a chart showing the variation in discharge flow rate with pressure for a given fluid, but seldom do they give definite information on the effect of viscosity changes. The lack of such information can be troublesome when contemplating a change to a different fluid of different viscosity, or even when using the same fluid at a different temperature and hence different viscosity. Therefore the following procedure should prove useful in extending makers' information to service conditions not covered in data sheets.

Pump slippage

Assuming the pump is dimensionally stable when under pressure and that the fluid is Newtonian, consideration of the slippage phenomenon leads to a simple model, Figure 1, in which the various leakage paths from the discharge side to the suction side are all represented by a single capillary. Here the

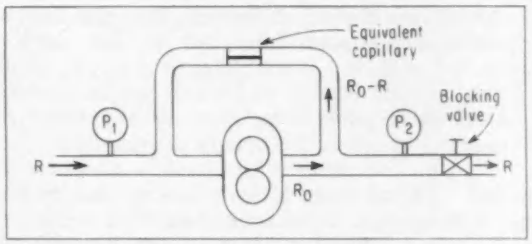


FIG. 1. Characterization of a metering pump as having one capilliary leak equivalent to all internal leakage paths simplifies analysis to determine pump performance.

slippage $R_O - R$ is represented by:

$$R_O - R = KP/V \quad (1)$$

where R_O = total flow rate, cu in./sec at zero pressure differential
R = discharge flow rate, cu in./sec at P pressure differential
P = pressure differential $P_2 - P_1$, psi
V = absolute viscosity, centipoises
K = a constant including the radius and length of the imaginary capillary

Examination of Equation 1 leads to the conclusions that, for a given pump:

1. Slippage at constant viscosity is a linear function of pressure, varying from zero discharge rate at zero pressure differential to 100 percent discharge rate at some finite pressure differential. Such a conclusion is verified in general by makers' pump curves, although such curves are somewhat irregular due to experimental errors, temperature variations, and perhaps distortion of pump parts.

2. Slippage at constant pressure differential is

inversely proportional to absolute viscosity. Again the conclusion has been substantiated by manufacturers' data as well as by extensive tests at Esso's pilot plant for continuous grease manufacture. (The only deviations observed have been when the suction port has been inadequate to permit entrance of a highly viscous product at the required rate.) This experimental linearity justifies the use of the Newton equation of streamline flow in developing Equation 1; for if the flow were turbulent, slippage would not be linear with respect to viscosity or pressure. Experimental linearity also indicates that viscosity changes due to pump friction heat are not significant.

3. Slippage is independent of rotary speed. This conclusion has also been experimentally verified.

Determining the K-factor

The K-factor in Equation 1 provides useful information about a given pump. For a given capacity a small K value indicates a high quality pump. The K-factor may be determined by two simple tests:

1. Run the pump at zero pressure differential and measure the discharge flow rate R accurately. Note that at zero pressure differential R equals R_o. To obtain zero pressure differential, the valve at R is opened wide, but if the differential is still greater than zero the suction pressure P_1 can be increased (perhaps by using compressed air to increase the head) to overcome the pump's pressure drop.

2. Run the pump at the maximum pressure P_2, with a thin fluid of known viscosity, and measure the flow rate R at the same speed as in step 1. (If the speed differs from that in step 1, correct R_o by the speed ratio.)

3. Then, $K = (R_o - R) \times V/P$ (2)

As an example of calculating the K-factor for a given pump and fluid, suppose the pump discharges 10.0 cu in./sec at 30 rps and zero pressure differential (step 1) and discharges 9.5 cu in./sec at 29.1 rps and 100 psi differential (step 2), with an oil having a 4-centipoise viscosity. Using Equation 2:

$$K = \left[10.0 \times \frac{29.1}{30.0} - 9.5\right] \times \frac{4}{100} = 0.0089$$

Under special circumstances the pump can be calibrated without actually discharging any fluid. The discharge line at R is pinched off ($R = 0$). Thus there is 100-percent leakage-flow recycle through the pump. Then R_o is the product of the pump's displacement D in vol/rev and the pump speed W in rps. Therefore Equation 1 can be modified to:

$$K = [(DW) - 0] \times V/P \quad (3)$$

Continuing from the preceding example, suppose $D = 0.33$ and at shutoff the pump generates a pressure of 4,250 psi at 28.3 rps. Then:

$$K = [(0.33 \times 28.3) - 0] \times \frac{4}{4{,}250} = 0.0089$$

Comparing pumps of different size

The K-factor is a figure of merit for pumps of the same rated capacity. However, it is often desirable to compare pumps of different sizes. For this purpose, a new figure of merit, the C-factor, is invoked. The C-factor is simply a pump's K-factor divided by the pump's displacement, yielding:

$$C = \frac{(R_o - R)\,V}{DP} \quad (4)$$

Assuming a maker exercises constant workmanship and design, pumps having different capacities but in a given series should have the same C-factor. That this is essentially the case is borne out by the plot, Figure 2, of C-factor vs displacement of a series of pumps produced by one manufacturer. Information like that in Figure 2 gives credence to the practice of some pump manufacturers who quote a single volumetric efficiency for a given series of pumps—for volumetric efficiency VE is related to the C-factor by:

$$VE = 100\,R_o/R = 100\left(1 - \frac{CP}{VW}\right)$$

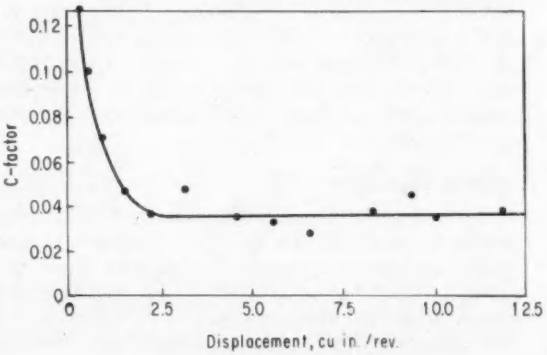
How wear affects pumping accuracy

Equation 1, or more specifically Equation 4, can be used to anticipate the pump's actual performance in a given service, particularly the effect of pump wear with time. Here the point of interest is the effect on discharge flow rate caused by a change in differential pressure at constant speed. Equation 4 can be rewritten as:

$$R = R_o - \frac{CDP}{V}$$

and differentiating with respect to P yields:

FIG. 2. In a given series of pumps, smaller size pumps have a larger C-factor. As pump displacement becomes greater, the C-factor decreases to an approximate constant value over a wide range of sizes, thus indicating that because of consistent design and workmanship within this range the C-factor for one size can be assumed to be the same for a larger pump.



$$\frac{dR}{dP} = \frac{CD}{V} \quad \text{and hence}$$

$$\frac{dR}{RdP} = \frac{1}{\frac{R_o V}{CD} - P} \quad \text{or} \qquad (5A)$$

$$\frac{dR}{RdP} = \frac{1}{\frac{WV}{C} - P} \qquad (5B)$$

For a given pump in a given service, the C-factor increases as the pump wears. From Equation 5A or 5B it can be seen that the larger the C-factor, the greater is the percent change in flow rate with respect to a change in differential pressure. While the pilot plant or process operator can periodically compensate for the effect of increasing slippage on discharge flow rate by correspondingly increasing pump speed, he can only do so until he reaches the top speed of the pump motor. Up to a point, then, desired flow rate can be maintained on an average. But, as Equations 5A and 5B show, a worn pump, with a larger C-factor, is more susceptible to a flow rate error due to a process disturbance, like a change in suction pressure, than is a new pump. Experience in using metering pumps in grease manufacture has indicated the desirability of pump replacement when dR/RdP exceeds 0.3 percent per psi.

In summary, the C-factor simplifies the selection of a metering pump for a specific service, aids in checking the wear rate of the pump once it is installed, and permits predicting pump performance for a change in service. These three problems will be evaluated in taking a process from the pilot plant to a full scale operation.

Scaling up pump size

In scaling up a pilot plant process, the conditions for full scale operation were to meter an oil of 30 centipoises at 39 cu in./sec flow and 50 psi differential. Tests were run on available laboratory size metering pumps, see table, as an aid in selecting a suitable larger pump in the same series. Spur gear No. 3 series was selected because the laboratory prototype had the smallest C-factor with which a plant size pump in that series could be obtained. In this case the pump selected had a displacement of 3.66 cu in./rev.

Then a calculation was made to check for the sensitivity of metering accuracy to changes in differential pressure. Recapitulating, $R_o = 39$, $R = 50$, $V = 30$, $D = 3.66$, and $C = 0.264$ (assuming C remains at the same value for the larger pump). Hence, from Equation 5A:

$$\frac{dR}{RdP} = \frac{1}{\frac{39 \times 30}{0.264 \times 3.66} - 50} = 0.00086$$

$$= 0.086 \text{ percent per psi,}$$

an acceptable value.

TYPICAL RATINGS OF SMALL METERING PUMPS

Pump	Displacement (cu in./rev)	C-factor
Spur Gear No. 1	0.037	0.003
Spur Gear No. 2	0.237	0.043
Spur Gear No. 3	1.174	0.264
Multipiston	0.428	0.017
Twin Piston*	0.012	0.003
Internal Gear	1.305	0.450
Screw No. 1	2.184	0.295
Screw No. 2	3.035	0.381
Vane	0.519	0.099

* Cam operated for nonpulsating flow.

Checking pump wear rate

Based on the preceding calculations indicating the proposed larger size pump would be satisfactory for the intended service, spur gear No. 3 pump with a displacement of 3.66 cu in./rev was purchased, tested, and installed. Periodic checks on the effect of wear on the C-factor showed the following history:

Months of service	C-factor
New	0.25
6	0.63
36	1.74

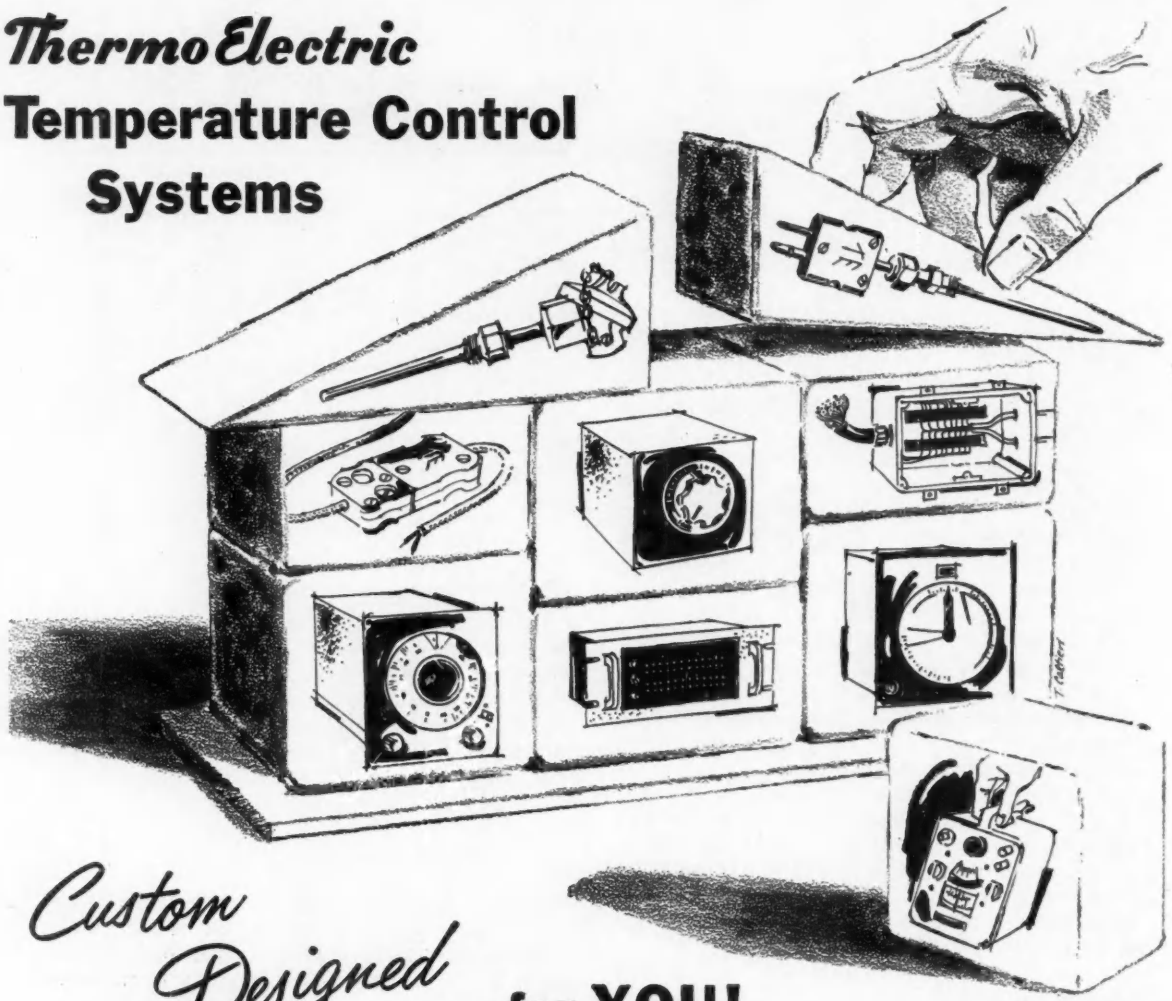
Note that the C-factor for the new larger pump (0.25) nearly equals the value for the smaller pump (0.264), thus again indicating that quality-made pumps in the same series have substantially the same C-factor. This history of pump wear indicates the pump was run for too long a period, because for the given case the allowable 0.3 percent change in flow rate per psi corresponds to $C = 1.0$.

Changing pump service

The question then arose as to how thin a fluid the pump—in its original condition—could handle and stay within the same criterion of 0.3 percent per psi. Using Equation 5A rearranged to solve for V and inserting the values stated previously, the minimum viscosity is found to be 9.5 centipoises.

The assumptions made herein are valid within engineering accuracy for metering and proportioning pumps handling Newtonian fluids. When such non-Newtonian fluids as emulsion or polymer types of hydraulic oils are pumped, the deviations from linear performance may be substantial. On the other hand, limited experience in handling Newtonian oils in elastomer-lined pumps (where the assumption of dimensional stability is invalid) has indicated that the relationships do not deviate as much as might be expected and are suitable as first approximations.

ThermoElectric Temperature Control Systems



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Logical Synthesis Plus Breadboarding Yields Gray Code Counter

The design of even simple digital control systems results in complex manipulations. Errors are easy to make and hard to find. Author Mergler shows the use of quantitative synthesis procedures for designing typical scaling logic and advocates a technique that may save you time and money. He checks a breadboard constructed of commercial logic modules before building the final system.

HARRY W. MERGLER, Case Institute of Technology

The availability of commercial digital assemblies that perform many of the more frequently encountered operations such as counting, frequency division, analog to digital conversion, encoding, and comparison has made it easier for the control systems engineer to apply digital control techniques. Such equipment often permits him to synthesize major portions of complete systems with off-the-shelf digital instrumentation. But in almost every case there are points in the system that require the design of specific logic assemblies to meet the special requirements of the system at hand. Here the control engineer must perform the logical design procedure, make sure the system performs satisfactorily, and develop the hardware configuration that will be used in the operating equipment.

Logical manipulations get complicated even when applied to simple digital systems. Mistakes are easy to make and hard to isolate unless there is an operating system to tinker with. And if an error isn't spotted until the final hardware has been constructed, it may force extensive rebuilding with the resultant expenditures of time and money.

There is a way of avoiding this possibility today. Compatible digital logic modules are available that permit a designer to breadboard his system and check it out before developing the final hardware. In fact some manufacturers have logic modules available in both developmental and final hardware form, so that the identical digital circuit that is experimented with in breadboard form is used in the final system. In this case the breadboard can be connected with the other digital assemblies and the complete system performance checked. Reference 1 lists some suppliers of logic units.

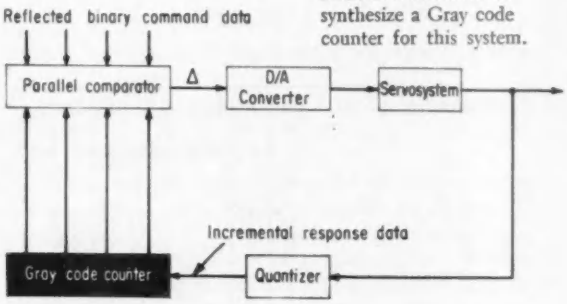

FIG. 1. Problem is to synthesize a Gray code counter for this system.

A portion of a control system used to investigate nonradix based codes in the Numerical Control Laboratory at Case Institute of Technology is developed to show the logical design procedure and the actual breadboard construction that was used to verify system performance.

The Problem

Contemporary numerical feedback control systems use both incremental (pulse counting) and absolute (coded) data and radix and nonradix based code forms. In some systems that use combinations of data forms and code bases, translators

or code to code converters are required to make the language of command and response the same at the point of comparison.

The system of Figure 1 uses absolute command data expressed in the nonradix based Gray code, and incremental unidirectional response data that must be converted to a Gray number proportional to the time integral of the data pulses produced by the quantizer as the controlled variable changes in magnitude. The circuit that is discussed here is constrained to perform the necessary counting operation directly in the reflected form.

The Logical Design Procedure

Consider only the first four counting stages (A, B, C, and D) of the Gray counter. The first and second columns of Table I show this reflected code for the first 15 counts, while the binary states at t_n and t_{n+1} are tabulated in the second and third columns.

The D binary (the lowest order digit) changes state every two input counts and is in the one state for the first count. This suggests a T (complementing) flip-flop as an input stage to the D binary. For a T flip-flop the state equation (Ref. 2) is

$$Q_{n+1} = Q_n\bar{T}_n + \bar{Q}_nT_n \tag{1}$$

Here Q_{n+1} is the state (0 or 1) of the flip-flop at $t = n + 1$ as determined by its state Q_n at time $t = n$ and the input T_n at $t = n$. Designate this extra binary flip-flop E and let its output E_n be the input T_n to the D flip-flop.

The logical design problem now consists of determining the expressions for binary inputs T_A, T_B, T_C, and T_D in terms of the conduction states of the binaries. The application equations derived from the third column of Table I are:

$$A_{n+1} = [\bar{A}B\bar{C}\bar{D} + AB\bar{C}\bar{D} + AB\bar{C}D + ABCD + ABC\bar{D} + A\bar{B}C\bar{D} + A\bar{B}CD + A\bar{B}\bar{C}D]_n \tag{2}$$

$$B_{n+1} = [\bar{A}\bar{B}C\bar{D} + \bar{A}BC\bar{D} + \bar{A}BCD + \bar{A}B\bar{C}D + \bar{A}\bar{B}\bar{C}D + AB\bar{C}D + AB\bar{C}D + ABCD]_n \tag{3}$$

$$C_{n+1} = [\bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \bar{A}BC\bar{D} + \bar{A}BC\bar{D} + AB\bar{C}D + ABCD + ABC\bar{D} + A\bar{B}C\bar{D}]_n \tag{4}$$

$$D_{n+1} = [\bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD + AB\bar{C}\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD]_n \tag{5}$$

Factoring Equations 2, 3, 4, and 5 yields equations of the form

$$Q_{n+1} = g_1Q_n + g_2\bar{Q}_n \tag{6}$$

which gives pairs of simultaneous Boolean equations that can be solved for

$$T_n = T_n(g_1g_2)$$

For all combinations of g_1, g_2, and Q_n, the values of Q_{n+1} and T_n can be calculated from Equations 1 and 6. This calculation is tabulated in Table II, and yields the following expression for T_n:

$$T_n = \bar{g}_1\bar{g}_2Q_n + \bar{g}_1g_2\bar{Q}_n + \bar{g}_1g_2Q_n + g_1g_2\bar{Q}_n \tag{7}$$

which reduces to

$$T_n = \bar{g}_1Q_n + g_2\bar{Q}_n \tag{8}$$

The factored application equations can then be algebraically reduced to obtain expressions for g_1 and g_2.

For flip-flop A

$$A_{n+1} = A_n(B + C + D)_n + \bar{A}_n(B\bar{C}\bar{D})_n$$
$$\bar{g}_1 = (B\bar{C}\bar{D})_n \quad \text{and} \quad g_2 = (B\bar{C}\bar{D})_n \tag{9}$$

For flip-flop B

$$B_{n+1} = B_n(\bar{A} + \bar{C} + D) + \bar{B}_n(ACD)$$
$$\bar{g}_1 = (ACD)_n \quad \text{and} \quad g_2 = (\bar{A}\bar{C}\bar{D})_n \tag{10}$$

For flip-flop C

$$C_{n+1} = C_n(\bar{A}\bar{B} + AB + \bar{D})_n + \bar{C}_n(A\bar{B}D + ABD)_n$$
$$\bar{g}_1 = (\bar{A}BD + A\bar{B}D)_n \quad \text{and} \quad g_2 = (\bar{A}\bar{B}D + ABD)_n \tag{11}$$

For flip-flop D

$$D_{n+1} = D_n(A\bar{B}\bar{C} + \bar{A}BC + AB\bar{C} + A\bar{B}C)_n + \bar{D}_n(\bar{A}B\bar{C} + \bar{A}\bar{B}C + AB\bar{C} + A\bar{B}\bar{C})_n$$
$$\bar{g}_1 = C_n(\bar{A}\bar{B} + AB)_n + \bar{C}_n(\bar{A}B + A\bar{B})_n \tag{12}$$

Referring to Equation 8 it is now possible to write specific equations for the flip-flop inputs

$$T_{An} = A_n(\bar{B}\bar{C}\bar{D})_n + \bar{A}_n(B\bar{C}\bar{D})_n = (\bar{C}\bar{D})_n(A\bar{B} + \bar{A}B)_n \tag{13}$$

$$T_{Bn} = B_n(AC\bar{D})_n + \bar{B}_n(\bar{A}C\bar{D})_n = (C\bar{D})_n(AB + \bar{A}\bar{B})_n \tag{14}$$

TABLE I

Binary States for Four-Digit Gray Code Counter

Count number	$[A\ B\ C\ D]_{t_n}$	$[A\ B\ C\ D]_{t_{n+1}}$
0	0 0 0 0	0 0 0 1
1	0 0 0 1	0 0 1 1
2	0 0 1 1	0 0 1 0
3	0 0 1 0	0 1 1 0
4	0 1 1 0	0 1 1 1
5	0 1 1 1	0 1 0 1
6	0 1 0 1	0 1 0 0
7	0 1 0 0	1 1 0 0
8	1 1 0 0	1 1 0 1
9	1 1 0 1	1 1 1 1
10	1 1 1 1	1 1 1 0
11	1 1 1 0	1 0 1 0
12	1 0 1 0	1 0 1 1
13	1 0 1 1	1 0 0 1
14	1 0 0 1	1 0 0 0
15	1 0 0 0	0 0 0 0

Gray code counting sequence

TABLE II

Equations 1 and 6 Yield These Combinations

g_1	g_2	Q_n	$Q_{n+1} = g_1Q_n + g_2\bar{Q}_n$	T_n
0	0	0	0	0
0	0	1	0	1
0	1	0	1	1
0	1	1	0	1
1	0	0	0	0
1	0	1	1	0
1	1	0	1	1
1	1	1	1	0

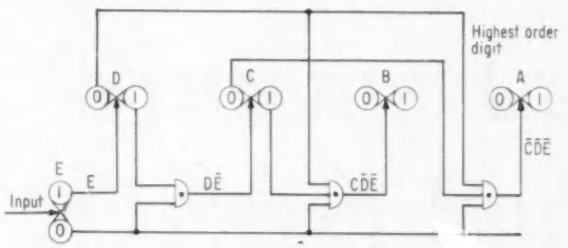

FIG. 2A

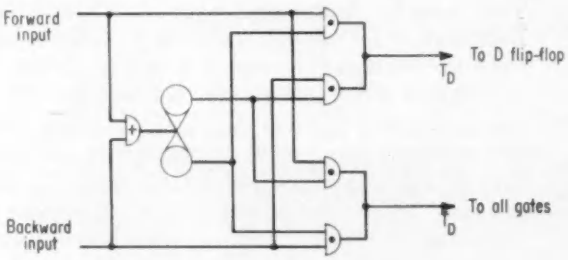

FIG. 2B

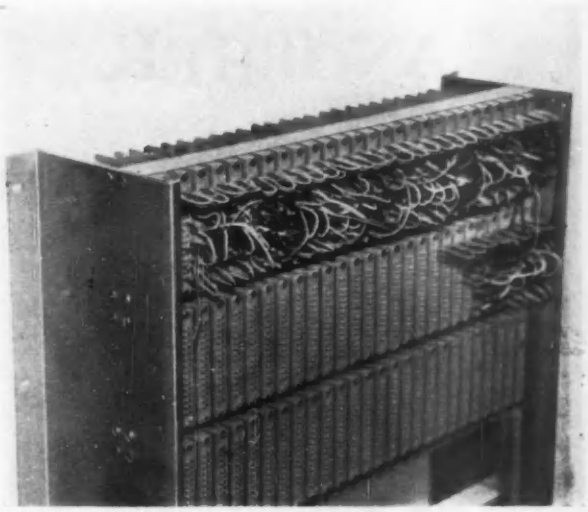

FIG. 2C

FIG. 2. Logical design for Gray code counter. A, input circuitry for making counter bidirectional, B and breadboard constructed from Wang Logical Circuitry, C.

$$T_{Cn} = C_n(\bar{A}BD + A\bar{B}D)_n + \bar{C}_n(\bar{A}\bar{B}D + ABD)_n$$
$$= (CD)_n(\bar{A}B + A\bar{B})_n + (\bar{C}D)(\bar{A}\bar{B} + AB)_n \quad (15)$$

$$T_{Dn} = D_n[C_n(\bar{A}\bar{B} + AB)_n + \bar{C}_n(\bar{A}B + A\bar{B})_n]$$
$$+ \bar{D}_n[\bar{C}_n(\bar{A}\bar{B} + AB)_n + C_n(\bar{A}B + \bar{B}A)_n] \quad (16)$$

Since E_n was designated equal to T_{Dn}

$$\bar{E}_n = [\bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}D + \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}BCD$$
$$+ ABC\bar{D} + AB\bar{C}D + A\bar{B}\bar{C}\bar{D} + A\bar{B}CD]_n$$

$$\bar{E}_n = D_n[C_n(\bar{A}B + A\bar{B})_n + \bar{C}_n(AB + \bar{A}\bar{B})_n]$$
$$+ \bar{D}_n[C(\bar{A}\bar{B} + AB)_n + \bar{C}_n(\bar{A}B + A\bar{B})_n] \quad (17)$$

New expressions must be formulated for T_C, T_B and T_A that will incorporate the expression for E_n.

$$T_C = D_n[C(\bar{A}B + A\bar{B}) + \bar{C}(\bar{A}\bar{B} + AB)]_n = (D\bar{E})_n \quad (18)$$

Similarly

$$T_B = (C\bar{D}\bar{E})_n \quad (19)$$

$$T_A = (\bar{C}\bar{D}\bar{E})_n \quad (20)$$

Equations 18, 19, and 20 precisely define the inputs to flip-flops C, B, and A and the logic diagram of Figure 2A can be drawn designating the interconnections between the output combinations of the T flip-flops A, B, C, D, and E and their inputs. If these rather complicated Boolean manipulations are correct, such interconnections will constrain the counting flip-flops to assume conducting states according to the reflected binary code sequence.

In actual servo applications the Gray code counter must possess bidirectional properties. The logical input circuitry for this purpose can be algebraically derived similarly and is shown above in Figure 2B.

The breadboard

The actual synthesis of the above circuits by means of Wang Logical Circuitry is shown in Figure 2C. Using this type of equipment for laboratory implementation of logical circuitry gives these benefits:

1) The logical design can be rapidly implemented without regard to the quantitative electronic design of the individual logic elements.

2) A rapid and positive means of evaluating the correctness of the logical design is provided.

3) The logic can be studied with regard to such critical parameters as pulse amplitudes, rise times, polarities, delay times, and noise.

Errors in Boolean manipulation are not readily recognized. Even in relatively simple systems the amount of manipulation provides such a favorable environment for error that many ideas are never explored beyond their logical equations because of the large time risk involved in the custom construction of special logic. Using standard logic modules for breadboard study removes much of this risk.

REFERENCES

1. *BREADBOARDING CONTROL SYSTEMS FOR DESIGN TESTS*, H. W. Mergler, "Control Engineering", September 1959, p. 164.
2. *LOGICAL DESIGN OF DIGITAL COMPUTERS*, M. Phister, John Wiley & Sons, Inc., New York, 1958.

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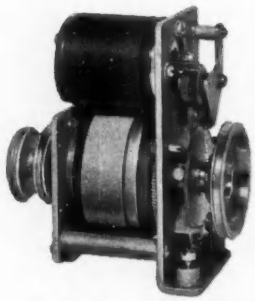

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Information Systems In Control Engineering

E. J. KOMPASS, Control Engineering

Information System

The following pages start a new feature department that will appear monthly under the title "Information Systems". It means concentrated coverage for the reader of an area of technology and equipment development which is demanding more and more of the control engineer's interest.
The department will bring together practical, authoritative articles on new techniques, equipment, applications, and principles in the generalized areas of data gathering, data transmission and storage, data reduction and processing, and information presentation.

An information system turns collected data into meaningful information. Business, industry, and the military are mechanizing important information systems as fast as the communications and computer arts permit. The object of this mechanization is better information about critical operating conditions in a shorter time. And when information systems become so fast that the information can be considered "current", automatic control is feasible. Thus the information system enters the control system and control engineering.

Four principal functions are recognizable in information systems: data gathering, data transmission, data processing, and information presentation, see Figure 1. The first and last are input and output functions for the information system. The transmission and processing functions may appear anywhere in the system in any order. Each of these functions can be mechanized in whole or in part by many techniques and many equipments already available: Figure 1 names a few and each should suggest others to the reader.

Mechanized information systems have already reached the level of automatic control: in business for inventory control and automatic customer billing; in industry for control of machine tools, unit operations and processes, and even whole production lines and operating departments; and in military operations for missile guidance and checkout, defense warning, and logistics systems. There are many other examples.

But the much larger number of off-line applications of information systems must also concern control engineers. First, because any information system is a dynamic system and its dynamics must be made compatible with the dynamics of the system in which it operates. Second, open-loop applications often suggest solutions for the closed-loop. And third, the end purpose of any information system is control in some sense, even if only indirect.

The information system fits into the control system as in Figure 2. It is apparent that its addition does not change the control system.

Figure 2 does, however, admit a new view of the general control system which undoubtedly should be taken by the engineers of systems that include extensive information handling. The new concept is that any control system can be considered as a measuring system plus an information system plus an actuating system. This view may also prove useful to control theorists for analysis of even simple systems. In this concept the information system is the decision-maker or brains of the control system. It can include means for calculating known or probable measurement errors, and if sophisticated enough and fast enough, can even make up for inadequacies in accuracy or speed of the actuating system.

Note that the input to the information system in a control application is measured or observed data. The output is information to be used in changing the measured condition. The word information is used here to mean data significant to the control problem as contrasted with the measured data which may be collected by more-than-adequate transducers. Thus data reduction (to information by our definition) is often implied in a control information system.

Note also that the inputs and outputs of the information system may be to physical systems or their human operators. The input and output arrows in Figure 2 which form the closed control loop exist sequentially in time, but the maximum time allowable in the information system depends on the system being controlled. Thus in some business systems where the effects of changing economic conditions may not be apparent for days or weeks, an information system of the traditional form involving much manual paperwork and memorandum passing may well produce some control of the business operation. But better control will generally require increased speed in the information system, hence mechanization and perhaps elimination of humans at the input and output.

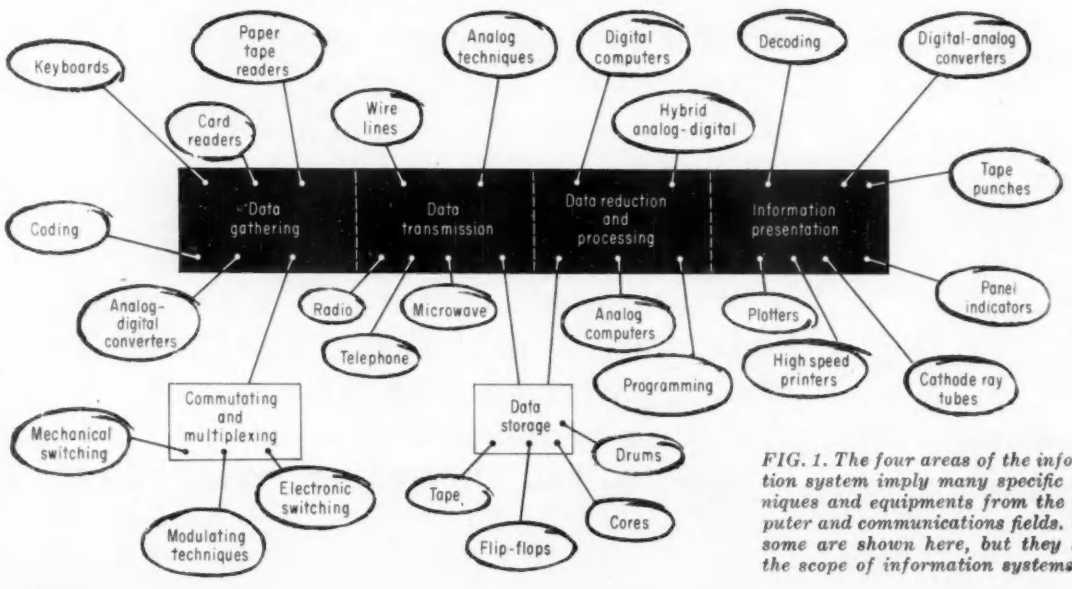

FIG. 1. The four areas of the information system imply many specific techniques and equipments from the computer and communications fields. Only some are shown here, but they show the scope of information systems.

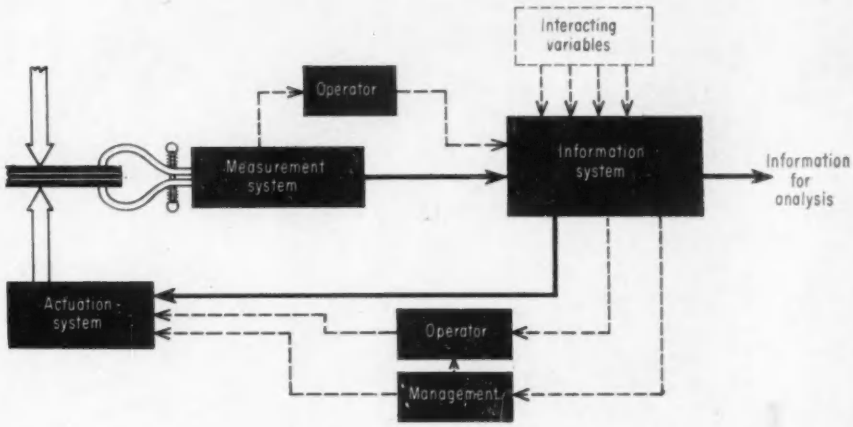

FIG. 2. Concept: a measurement system plus an information system plus an actuation system equals a control system.

Control engineers will serve business as well as industry

What practical effects will the advent of information systems in control have for control engineers? Idealizing for the moment, it means that all operations on measured data up to the point of actually changing the conditions (actuation) can be considered merely information handling and processing operations. But the arts and techniques of handling and processing information have already been highly developed in the computer and communications industries. So it is natural from the information systems view that control systems should come to include a high content of equipments from these industries.

In process control systems where large amounts of data must be handled at high speeds to develop a real-time control signal, the use of computer equipment and electronic data communications is natural and sometimes the only feasible solution. A number of such systems are already operating in the chemical and petroleum industries (Refs. 1 and 2). Others are running steam power generating stations in the electric utility field with many more contracted for. Still others are now being built for computing control of steel rolling mills (Ref. 3).

And in business systems also the techniques and equipment of information systems are being put to work to mechanize those portions where more complete and up-to-date information can pay off in better control. There are many operating examples in production control systems, inventory control systems, shop order locating systems, and even broader manufacturing control systems in which the computer is time-shared among the various jobs on a priority basis (Ref. 4).

And the military services, too, have been pressing their systems contractors for maximum mechanization of information systems at every level from analysis of experiments to automatic trajectory control of space vehicles, from production line quality controls to automatic prelaunch system checkers, and from temperature monitoring systems to defense warning networks (Ref. 5).

Really sophisticated control of even complete businesses with hundreds of independent and interacting variables affecting optimally correct control levels is already feasible with today's computers. But progress in the control of such many-faceted dynamic systems will largely follow the successes of systems analysts and operations research teams in their attempts to determine sets of interrelated equations which adequately describe such systems. Completely automatic control of very large systems will therefore be a goal for a long time to come.

In the meantime, business managers will continue to recognize the value of improving and speeding the information available to them about the more important operations within their businesses, and they will detect bottlenecks in minor operations which slow the important ones. Control engineers have already developed much of the know-how to mechanize critical business operations in their work with process and production control systems. With such knowledge, control engineers will design such subsystems for business control—whether the business is missiles or manufacturing, or even banking or merchandising.

The common denominator in these seemingly unrelated applications is the control engineer's familiarity with the characteristics of dynamic systems plus his broad knowledge of available equipments in the information systems area and their relative abilities and advantages when used in dynamic systems. This most important view of the dynamic effects of data processing equipment when used on-line in larger systems is almost uniquely the control engineer's.

REFERENCES

1. *CLOSED-LOOP COMPUTER CONTROL AT LULING*, R. D. Eisenhart and T. J. Williams, "Control Engineering", November 1960, pp. 103-114.
2. *COMPUTER LOGGER EASES GAS DISPATCHING JOB*, "Control Engineering", June 1959, p. 23.
3. *BRINGING HOT STRIP MILLS UNDER AUTOMATIC CONTROL*, D. Bristol, "Control Engineering", September 1960, pp. 146-149.
4. *MANUFACTURING CONTROL WITH A 705*, J. M. Cherba, "Control Engineering", May 1960, pp. 132-137.
5. *HOW THEY KEEP THOR OPERATIONAL*, "Control Engineering", December 1959, pp. 80-94.

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7776 to 1	1.5	100 oz. in.	0.090 max.	2.980	E171
9168 to 1	1.25	100 oz. in.	0.085 max.	3.140	E179
4056 to 1	2.75	100 oz. in.	0.100 max.	2.980	E215
2923 to 1	4.00	100 oz. in.	0.120 max.	2.980	9001-05
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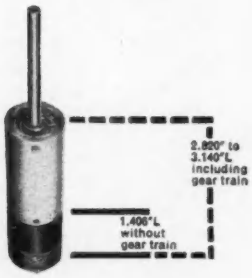

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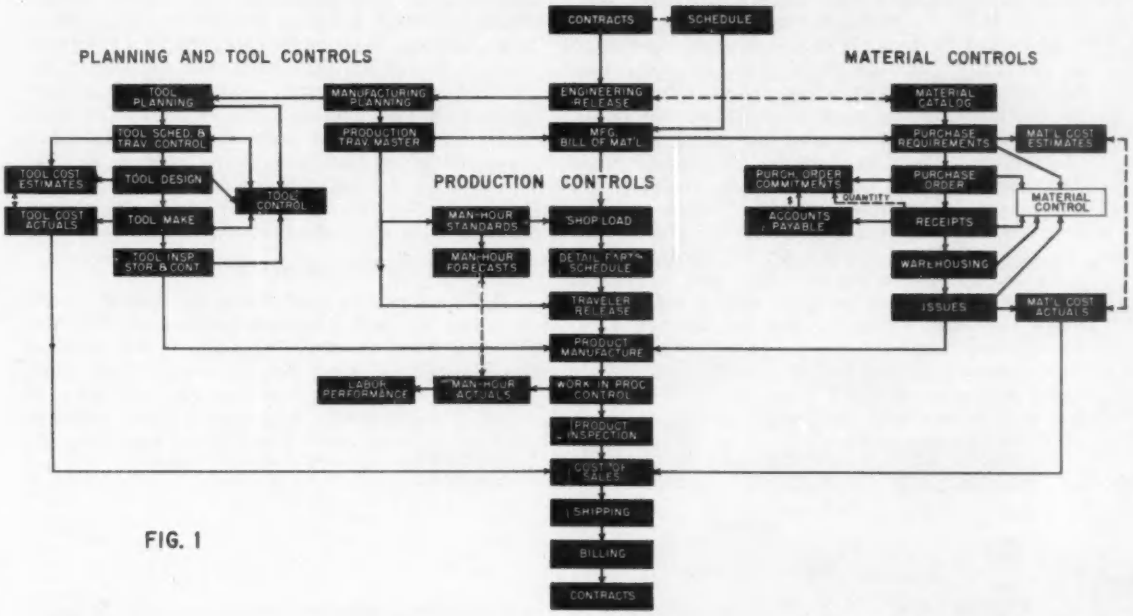


FIG. 1

Job Shop Production Control on a Computer

Consolidating paperwork into a single organization, run by a computer, reduced Bell Helicopter's inventory by $500,000 and cut manufacturing lead time on helicopters in half.

MARVIN REID, McGraw-Hill News

Setting up the repetitive paper handling that makes automatic data processing so attractive is not so easy in a job shop because each job moving through the plant can be quite different. To manufacture a complex piece of machinery like a helicopter complicates the problem additionally because the manufacturing takes so long, requires so many different machinery and testing operations, and uses such a large number of materials and component parts. One approach to this problem is the all encompassing data processing system now being installed at Bell Helicopter Co.'s Fort Worth, Tex., plant.

With this new system Bell will bring all major manufacturing record and control systems into one functional organization. This includes buying, receiving, storing, production, shipping, billing, and manufacturing accounting. Eventually the organization will also include such subsidiary activities as shop loading, labor forecasting, statistical quality control, and production simulation. Sometime in the future Bell may even try to convert engineering design information into computer terms, so that engineering paperwork will flow into production paperwork smoothly.

The over-all system is illustrated in Figure 1, though it is not yet completely installed. It has been designed to do three main jobs: material controls, production controls, and planning and tool controls. At the start the system will operate on an IBM 650. Later this year a new IBM 1401 machine will replace the older unit.

One of the first implementing steps that had to be taken was to integrate and automate all working paper and record files. The new computer-processable files have produced tremendous

time and space savings. For example, material catalogs previously were kept in four places. Now they have been consolidated into a single punched card record center. Within hours of receipt of an order for follow-on production—an order that requires no new engineering design—the system accomplishes all the work of exploding the order into terms of scheduled materials, parts, and subcontracting. Reading from the all purpose basic files, the computer spells out total material requirements, determines which of these are in inventory in sufficient quantities to complete the job, and lists those which must be purchased.

To set up such a file Bell first had to catalog some 40,000 items of material and to establish a single, uniform coding system for identification. In addition to providing the base for electronic data processing, the coding arrangement eliminated confusion resulting when one person identifies a part one way and another calls it by a different name or number.

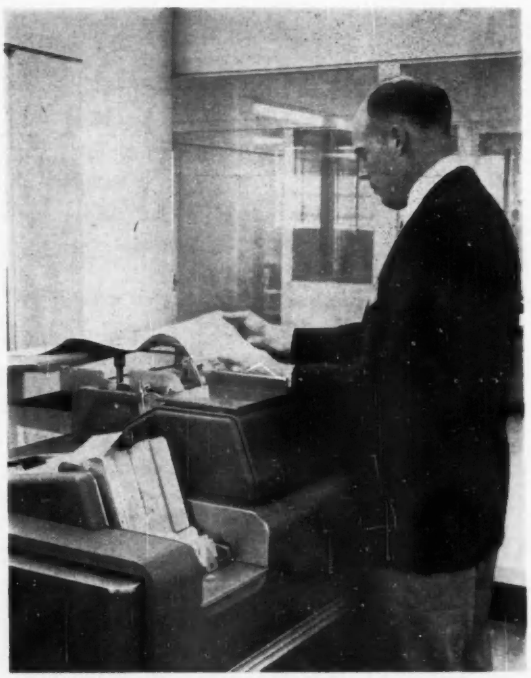
Previously this had been an annoying and expensive problem. In one case before the master catalog was developed, the engineering department had described four different antennas from four different vendors by each vendor's identification—although all four had equal capability and were of comparable size. At one time a shortage existed in one type and procurement was expedited, while one of the other types—which would have served as well—was being sold as surplus. By defining a requirement and cataloging it, all four antennas were put under one material code number with alternate procurement authorized.

Source files in the computer

Bell's entire new manufacturing control system is based on such computer-processable files and integrated techniques. The company has prepared basic tape and card files to provide the single source—and common language—to all requirements: contractual, materials, labor, tooling, factory routing, etc. There is no secondary file system. The basic files include these:

Keypunch operators prepare master files on punched cards;

Computer performs subroutines required by integrated system;



Tabular printout is one output of system; punched card is another

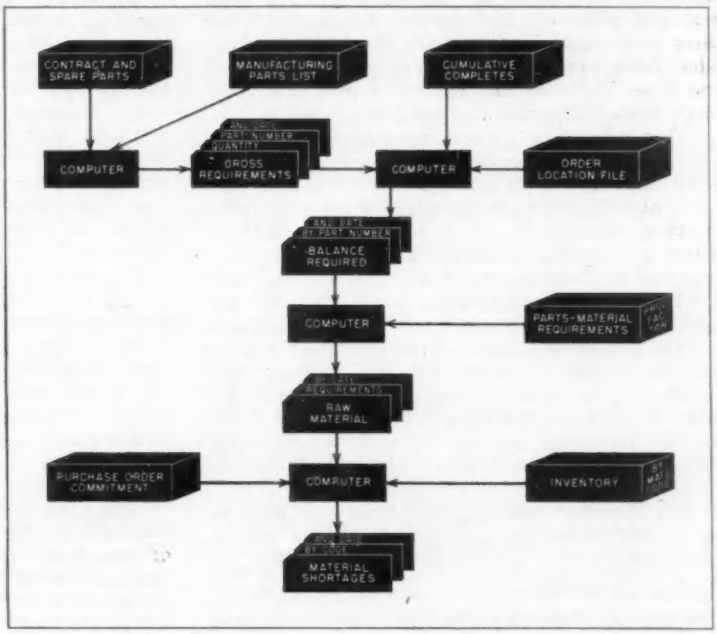
▶ Contract Requirements—Key sales information for determining the backlog of business. Identifies each contract in work by project and model, work order, helicopter unit number, requirement date, dollar value, and other pertinent descriptive data. The computer uses this file to establish gross contract requirements, in forecasting income, for various analytical reports, and as input for its gross requirements for production.

▶ Engineering Assembly Parts List File—One of three files maintained by the Data Release Group, this is a direct reflection of the engineering drawing. It shows the quantity of materials, parts, and subassemblies going into each assembly. In addition, each item is coded for ship effectivity, type of part, schedule index, and subcontract status. These lists are released to production with the engineering documents. An average helicopter model has about 35,000 parts list entries.

▶ Manufacturing Assembly Parts List—This is

FIG. 2.

HOW MATERIALS ARE CONTROLLED



Step 1. *Gross requirements are determined.*

After a punched card containing information about the contract is inserted, each card in the manufacturing assembly parts list is read into the computer. Then the quantity of the part required by the order is computed; a table-lookup is performed to determine the number of days required to supply the part or material; a check is run to ascertain that the part specifications are still effective; finally a requirement card is punched out indicating by code: the type of part or raw material replacement, ship requirement or spare part, and make or buy.

Step 2. *Balance required is computed.*

To determine the balance required, the computer subtracts from the gross requirements two elements: items in the **Cumulative Complete** file and in the **Order Location** file. The former is kept up to date with traveler cards that report the total completed parts by part number made by the shop as the work is completed. The latter has a card for every traveler card in the shop and indicates where each traveler is. Completed parts in stock are subtracted from the gross requirement as are parts in process that will be complete by the time the specified order will need them. A **Balance Required** card is punched for all items that need to be made. In addition, stock shortage notices are punched for items which are behind schedule, and excess stock notices are punched out if complete parts and work in process go over contract requirements.

Step 3. *Raw material needed is determined.*

Combining **Balance Required** cards with the **Parts-Material Requirements** file in the computer converts part numbers to material codes, computes the amount of material required, allows a material loss for scrap, and punches out a raw material requirement card.

Step 4. *Material shortages are spotlighted.*

The **Raw Materials Requirements** output, **Purchase Order Commitment**, and **Inventory Files** are combined to find material shortages. Shortages are identified as items that have not been ordered by the purchasing department, are not in inventory, or are not in process.

a record of the planned manufacturing buildup of the end product. It incorporates latest manufacturing and assembly methods specified by the Production Engineering Dept. on planning and operation sheets. It also is maintained by the Data Release Group.

▶ Parts-Material Requirements File—Last of the files maintained by the Data Release Group, this provides an up-to-date record of material code, description, and quantity required to make each detail part. It is the link between the Manufacturing Assembly Parts List and two material files, the Inventory File and the Purchase Order Commitment File. Material Coding provides the common denominator. Information for each of the three files maintained by Data Release is assimilated from engineering drawing bills of material and from planning and operation sheets. It is incorporated into the applicable files nightly.

▶ Order Location File—This record contains all of the necessary information to control production work in progress. It is constantly updated by the latest direct labor time charges to show shop order location, cumulative actual hours, and estimated hours to complete (standard less actual to date). Material requisitions update material costs to date.

▶ Parts-Tool Requirements List—This file relates families of tools directly to the part or parts on which they are used. It is combined with a Tooling Order Location File to produce tool reports. The location file, created as the tool order is released, carries a wide variety of information including account number, usage effectivity, priority code, schedule and actual completion date, and estimated and actual cost.

How these are used in subroutines is illustrated by the control system in Figure 2. Others will be combined for production control and planning.

Adding up benefits

One of the most significant savings of time and money accrues from the periodic summary of operations by the computer to monitor manufacturing activity. Each week the computer reviews the status of the total backlog of business in the plant (currently running about $50 million) and picks out trouble spots: orders that are behind schedule or are over budget.

Bell's management lists these specific examples of benefits already received from the installation:

• Availability of up-to-the-minute production data. Continuing contract status reports show actual dollars and hours expended to date on each contract and compare this to budgeted dollars and hours. Backup information is available at any level—by end product, assemblies, or parts.

• The ability to forecast material requirements with increased accuracy helped reduce inventories. The computer also surveys all inventoried items for obsolescence. It picks out items which have become obsolete both as a result of design changes and changes in specification designation. As a result, the purchasing department buys materials that conform to latest specifications.

• Availability of basic data on all production models in tape files has cut the lead time on follow-on orders. A costed bill of materials, either for production or for bidding purposes, can be prepared in two hours. Information such as raw material and vendor parts required, tools needed, and labor requirements are instantly available.

• Duplication of effort, clerical work, and elapsed time in the release and utilization by manufacturing of engineering information has been cut. One department, the Data Release Group, simultaneously transcribes information from engineering documents and/or planning sheets for all manufacturing uses. Previously, all departments using assembly parts lists had to do their own transcribing. This required duplication of effort and files in production control, spare parts, estimating, service, planning, and subcontracting.

• A system for collection of basic data from the factory provides for action files needed to control work in progress and supplies normal labor and material distribution information. Each direct labor time charge is accomplished by location of the shop order being charged, thereby adjusting the shop order location file. Material changes adjust inventory files while on their way to distribution over Bell's Chart of Accounts.

Engineering cost and time data are currently recorded apart from the electronic data processing system. Management hopes later to expand the system to pick up each new contract with its release to engineering and to control its flow through the engineering design process much as shop orders are controlled through manufacturing.

When this installation is complete, Bell has even more ambitious plans. The next logical step, says department head Tom Fisher, is for the engineer to define his design in computer terms for direct computer input. The computer will compute angles of attack, cutting paths, and so forth and will prepare the tape which will result in automated end production when fed into the director unit of a machine tool.

To accommodate the hardware required for the new production control system, Bell added a new $1 million, 10,000 sq ft wing to its plant. Bell management also formed a special Data Processing Dept. to operate the new program.

At the start an IBM 650 computer with supporting peripheral equipment was installed. Then the computer's capabilities were doubled by the addition of an IBM 543 card reader, a 544 card punch, and six magnetic tape units. The new card equipment updates master files by 250 cards per min.

Next step is to replace the 650 with an IBM 1401 to speed up operations even further. With the new machine the transmitting system will print 600 lines per min compared to 150 lines per min at present. And the 1401's tape handling speed will be 62,500 characters per sec compared to 15,000 per sec with the IBM 650.

Cost of this installation is running about $1 million per year, a figure that includes a direct budget of $670,000 per year for equipment rental and operating overhead. The biggest payoff so far has been in enabling the company to reduce its inventory by $500,000 and by cutting the lead time on helicopters by 50 percent.

Unique Plotting System Turns Digits Into Curves

THE GIST: Where a sufficiently large average volume of plotting justifies the preparation of a special format magnetic tape, this unique system for continuous curve plotting of digital computer results can save considerable time and eliminate operator errors. Plotting is done on standard X-Y or strip chart recorders. The system is kept simple by placing the operational burden on the computer subroutines used in preparing the plotter tape. Control of the plotter is thus in the hands of the computer programmer, in keeping with present trends in digital off-line equipment.

MITCHELL BAIN, Jet Propulsion Laboratory
ROBERT N. FLANDERS, F. L. Moseley Co.

Five different approaches to the problem of plotting digital computer results are used in systems currently available, as shown in the table on the next page. The cost and complexity of these systems are directly related to plotting speed. Selection of one of these types as the plotter for a particular computer installation thus depends usually on the volume of plotting that is expected to be done, although maximum available plotting speed must sometimes be the criterion. Type 3 of the table is represented by the Moseley Type 575 system, which is unique in that it plots digital results by drawing continuous curves at the rate of 4 in. per sec. Equipment is simple because the special computer-prepared magnetic tape used as input contains all operational data for the plotter. The 575 system is similar to the point plotters of Type 2 with the following differences:

- Continuous curves are plotted by placing many points close together, typically 25 to the inch, and leaving the plotter pen in contact with the paper so that the plotter draws a smooth curve.
- No editing is required of the data since the tape is written specifically for plotting in a fixed format. In particular, scaling and zero offsetting are handled in the computer routine.
- The operator's job is reduced to simply monitoring the operation. Plot labeling, raising and lowering the pen, and (in some versions of the system) changing paper are under tape control.
- The system also plots curves on strip chart recorders where the "time" axis is tape controlled.
- The time necessary to prepare the tapes on the computer and execute the plots is less than the time needed for comparable plots prepared on a magnetic tape point plotter using the tabulator (off-line) tape.

This last point needs elaboration. To plot continuous curves the tape contains hundreds of points per curve instead of the dozen or so used in point plotting from a tabular tape. Scaling and zero offsetting are done by transformation routines in the computer. Hence the total computing load has been increased. Nevertheless the time taken by the computer to write the plotting tape has not been increased. The reason for this seeming paradox is the elimination of the end-of-record gap requirement of IBM off-line magnetic tapes (to tabulator or card punch).

Each point of an off-line tape must be written in a record separated by the end-of-record gap, ¾ in. of blank tape, from the next point or record. Consider a curve defined by points spaced each ¼ in. on the graph. If the curve is 15 in. long, then 30 points are plotted with a magnetic tape point plotter (Type 2), while 375 "points" are needed after interpolation for the continuous curve plotter.

The 30 points needed for the point plotter are written in 30 records, each of two IBM words. One defines the X coordinate and the other the Y coordinate. At ¾ in. spacing per record, the total length of tape required is 24 in.

The 375 "points" of the continuous system are packed into a single record, 375 words long. This record requires 12 in. of tape (IBM records 33⅓ words per in. of tape). The continuous system

Quick Guide to Digital Plotting Systems

Type	Source of data	Description of system	Speed	Remarks
1	Byproduct of tabulation	Semiautomatic hand plotting	Slow	Operator reads tab sheet and punches data in keyboard-controlled point plotter. Process is therefore a byproduct of tabulating. Good for occasional plotting.
2		Automatic point plotting	100 points per min	Slow speed limits process to small volumes of data. Digits to be plotted are read automatically from punched tape, punched cards, or magnetic tape prepared originally to drive tabulator printer. Plotting equipment must edit data (select abscissa and ordinate scales, select significant digits, adjust zero position, determine beginning and end of run).
3	Generated directly by specially prepared computer routines	*Continuous curve plotting on X-Y or strip charts*	*4-in. curve per sec*	*Special magnetic tape for plotter control is written by general purpose computer subroutines. Data on tape is thus already edited. Special data format used on tape permits continuous reading and high speed plotting. Automatic plot labeling available. System described in article.*
4		Multistylus facsimile plotter	Paper speed 1 in. per sec	Special magnetic tape for plotter control is written by general purpose computer subroutines. Particularly adaptable to plotting of time records such as encountered in missile telemetry and rocket engine test data reduction. Usually justified by handling tabulating chores in addition to plotting.
5		*X-Y* cathode ray tube to microfilm	Very fast, usable on-line	Special computer prepared tape may be used, but some versions can work on-line, in which case no tape is necessary. Types 4 and 5 make finished plots with labels to good accuracy because graph lines are drawn with plot of data. New computer tabulators are fast enough that tabulating on these expensive machines may not be desirable.

Increasing cost and complexity ↓

thus gives a 2 to 1 saving in tape and a 2 to 1 saving in tape writing time by the computer.

If the point plotter can plot 100 points per min, then the 30 points of the curve require 18 sec. The continuous plotter can draw the same 15-in. curve in 4 sec.

In actual practice the analysis just made is never as simple as in this hypothetical case. Records for off-line tabulating are usually longer than two IBM words, and many plot points can be written in a single record to be picked up in repeated passes of the tape.

But the analysis given does reveal why plotter systems of Type 2, designed to read off-line tabulator tapes, are unsuitable for drawing continuous curves by placing many points close together. The percent of tape wasted by the end-of-record gap increases as the spacing between points on the graph decreases. It is evident that to use an off-line tabulator tape for drawing continuous curves requires that a special tape be written in addition to the tape used to drive the tabulator. The points needed to define the curve are too dense for a reasonable tabulation.

Figure 1 diagrams the magnetic tape continuous curve plotting system designed for reading IBM binary tapes. The computer tape is read at 3 in. per sec or less, and the bits read off the tape are shifted through a 6 x 6 shift register. When a complete IBM word is detected, the instruction portion of the tape is interpreted and the data acted on accordingly. For example, the 12 bits of the word defining the *Y* variable may be transferred to the 12-bit digital to analog converter controlling the *Y*-axis servo on the plotter.

The word format used for binary tapes is

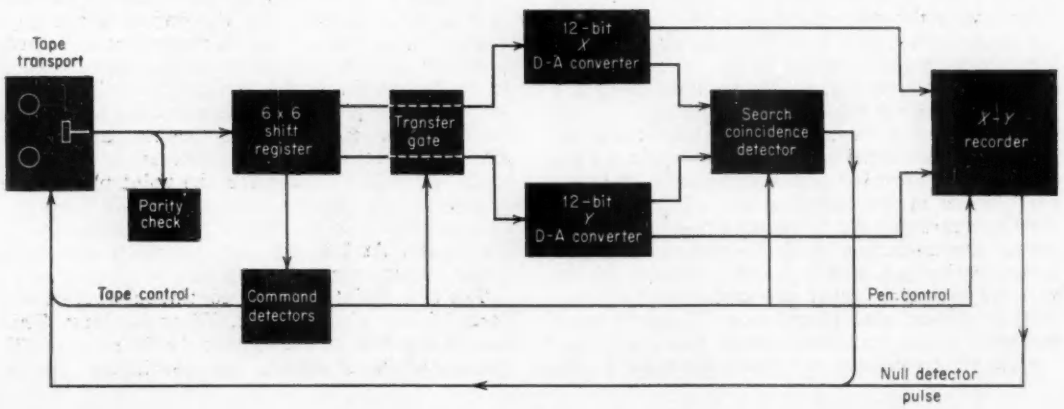


FIG. 1. Block diagram of automatic continuous magnetic tape digital plotting system.

sketched in Figure 2. Each word of 36 bits contains 12 bits of X data, 12 bits of Y data, 6 bits of word identification, and 6 command bits.

The tape transport reading the computer tape runs at 3 in. per sec or less. The word rate into the shift register is 100 words (100 X-Y coordinate pairs) per sec. If 25 points define 1 in. of curve under computer control, the plotting rate is 4 in. per sec. At this speed if the curve is well behaved the plotting accuracy is better than 0.2 percent of full scale. More sophisticated subroutines vary the point density and therefore the plotting speed according to the behavior of the curve.

The plotter scale factor is fixed at 3,072 counts along the X axis and 2,048 counts along the Y axis with the origin in the lower left hand corner when a standard 15 x 10 in. plotting grid is used. Checking paper position and sensitivity is there-

TAPE FORMATS

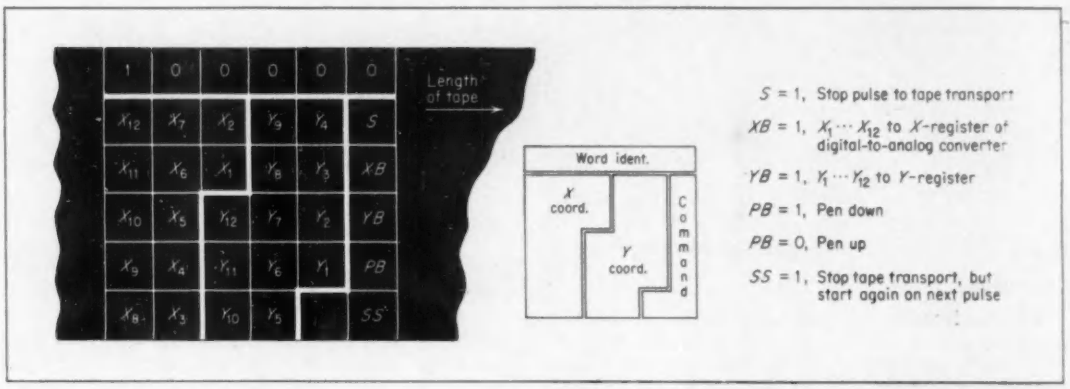

1 0 0 0 0 0
Length of tape
X_{12} X_7 X_2 Y_9 Y_4 S
X_{11} X_6 X_1 Y_8 Y_3 XB
X_{10} X_5 Y_{12} Y_7 Y_2 YB
X_9 X_4 Y_{11} Y_6 Y_1 PB
X_8 X_3 Y_{10} Y_5 SS
Word ident.
X coord.
Y coord.
Command
S = 1, Stop pulse to tape transport
XB = 1, $X_1 \cdots X_{12}$ to X-register of digital-to-analog converter
YB = 1, $Y_1 \cdots Y_{12}$ to Y-register
PB = 1, Pen down
PB = 0, Pen up
SS = 1, Stop tape transport, but start again on next pulse

FIG. 2. Word format used on IBM binary tapes. Typically, 25 such words are used per inch of plotted curve. No gaps are required between words on the tape.

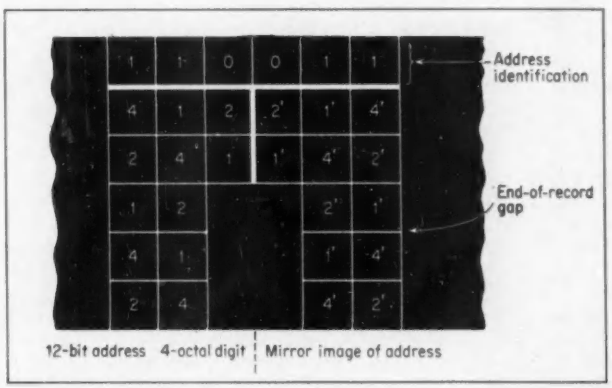


FIG. 3. Address word format used at start of each curve is separated from continuous curve recording format of Figure 1 by ¾-in. end-of-record gap, can be read from either direction at maximum search speeds to locate beginning of curve.

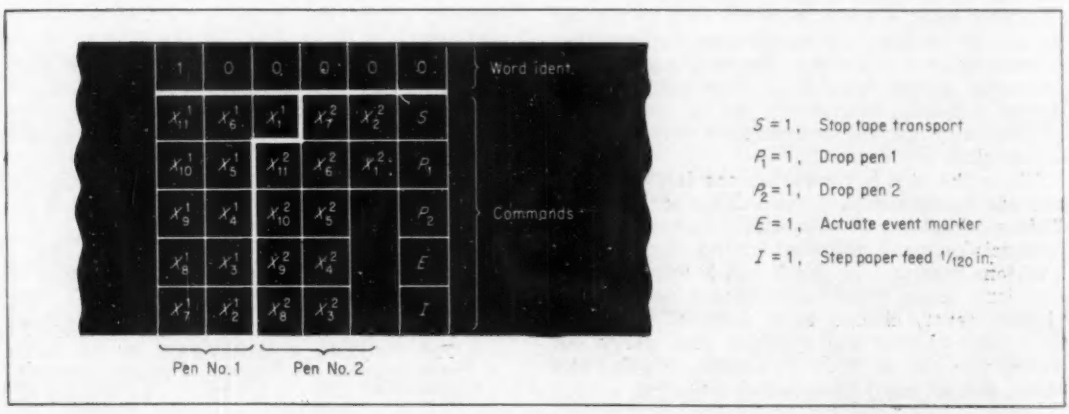

1 0 0 0 0 0
Word ident.
X_{11}^1 X_6^1 X_1^1 X_7^2 X_2^2 S
X_{10}^1 X_5^1 X_{11}^2 X_6^2 X_1^2 P_1
X_9^1 X_4^1 X_{10}^2 X_5^2 P_2
Commands
X_8^1 X_3^1 X_9^2 X_4^2 E
X_7^1 X_2^1 X_8^2 X_3^2 I
Pen No. 1
Pen No. 2
S = 1, Stop tape transport
P_1 = 1, Drop pen 1
P_2 = 1, Drop pen 2
E = 1, Actuate event marker
I = 1, Step paper feed 1/120 in.

FIG. 4. Word format used for controlling strip chart recorder uses 11-bit binary codes to locate each of two pens within plus or minus 0.0025 in. on a 10-in. wide chart.

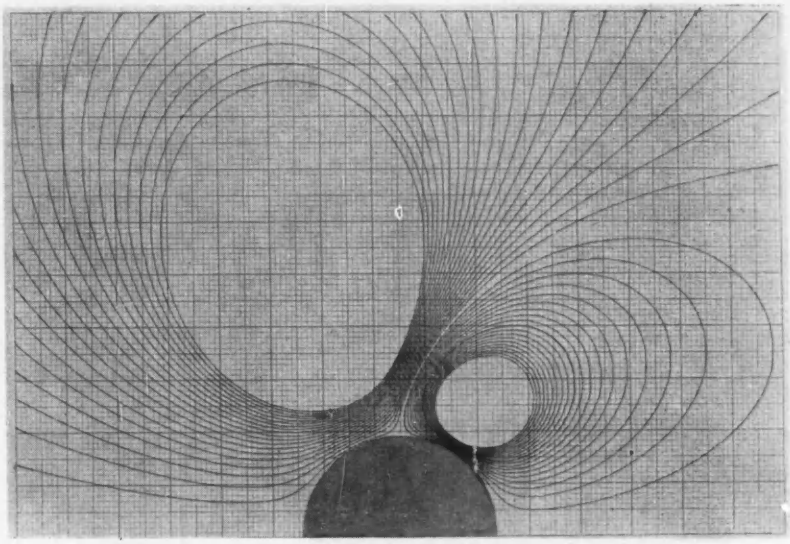


FIG. 5.
Electromagnetic fields of cryogenic gyro plotted automatically by continuous plotter described. (Courtesy of Jet Propulsion Laboratory, Pasadena, Calif.).

fore simple since the adjustments never change.

Operation is easy

The beginning of a curve or family of curves is addressed on the tape by the special computer word sketched in Figure 3. This address word precedes the curve and is followed by an end-of-record gap. The address is a four-digit octal number enumerated from the beginning of the tape. To find a curve the operator enters the desired address into the *Y* register by means of the push-buttons. Switching the equipment to the search mode allows the tape transport to run at its maximum speed: 9 in. per sec on the Potter Instrument Co. Model 3280 and 30 in. per sec on the Shepherd Industries DT series. Reaching the sought address the tape automatically stops and plotting can begin. Searching can be done in either direction; note the symmetrical way the address is written, Figure 3.

Upon pressing the start button the tape begins to read the beginning point of the curve. This point is written with the commands $PB = 0$ and $SS = 1$. Thus the pen is up while the plotter is slewing to the beginning of the curve. On reaching null a start pulse is sent to the tape transport. The next point is read. Now $PB = 1$ so the pen drops. By storing code numbers in the computer subroutine it is possible to generate a pattern of ones and zeroes for *PB* so that solid, dashed, dotted, dot-dash, etc. curves can be drawn. Alphanumerics can be conveniently written with appropriate subroutines.

When the plot is completed, the last word has the stop command $= 1$ with XB and $YB = 0$. This combination of command bits energizes an annunciator panel controlled by bits stored in the positions reserved for the *X* and *Y*-coordinate bit positions. Some typical annunciator legends are: change paper, change to a different color ink, find next address and continue plot, carry out instruction (A, B, C . . .), change to point plot mode, change point plot symbol, and stop.

If an automatic paper changing recorder is used, the last word is written with $S = XB = YB = PB = 0$ and $SS = 1$. This combination triggers the paper changing mechanism which then restarts the tape handler upon completion of its cycle. Automatic sequencing of the symbol changing mechanism is handled similarly with the address of the new symbol written in *X* or *Y*-coordinates.

Plotting on strip charts

Figure 4 shows a tape format for driving a two-pen strip chart recorder. Note that only 11 bits are necessary to control each of the pen positions since pen travel is limited to 10 in.

The F. L. Moseley Co. Model 80A strip chart recorder has a unique feature which allows the paper position to be accurately incremented with a pulse. One inch of paper travel requires 120 pulses. At 3 in. per sec tape speed and $I = 1$ for every word, the maximum paper speed is 0.832 ips.

Being able to control paper speed with the *I* command bit means that an unusually accurate plot is possible. Limitations in pen servo dynamics are not significant so that the record can be "violent" and not affect the plotting accuracy.

Another advantage of having the paper drive under computer tape control is that the tape transport need not be accurate in speed as would be the case if the paper drive were a true time base. Also the paper can be returned to the origin for accurately positioned multiple plots.

The magnetic tape controlled continuous plotting system can also generate arbitrary functions for analog computers or control machine tools.

REFERENCES

1. *HIGH SPEED PLOTTING OF TELEMETERING DATA, Robert L. Sapirstein, "Electronics", January 8, 1960.*
2. *EFFICIENT LINKAGE OF GRAPHICAL DATA WITH DIGITAL COMPUTERS, E. D. Lucas, "Proceedings of the Wescon Computer Sessions", August 25-27, 1954.*

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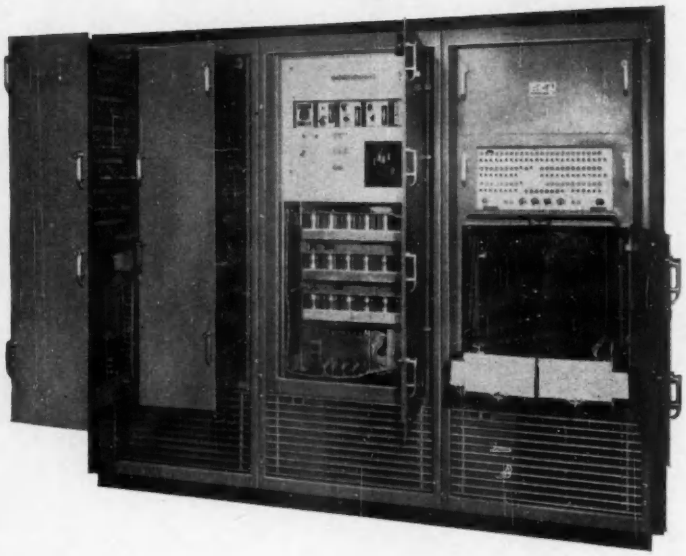

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Two Ideas in Checkout Systems:

1. Automobile Checker Controlled by 35 mm Projector

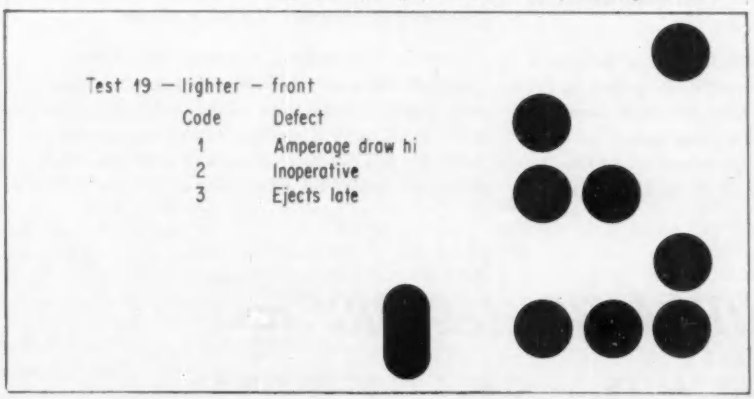
WESLEY PERRY, JR., McGraw-Hill News

FIG. 1. Automatic tests on Lincoln-Continental's electrical system are initiated and recorded by operator according to instructions and results projected on screen.

The Lincoln-Continental Div. of Ford Motor Co., which reeently extended its warranty from 3 to 24 months, is now using a new electronic analyzer to check the quality of the electrical systems in Lincoln-Continental automobiles. Called EAGER (Electronic Analysis GagER), the unit was designed by Performance Measurements Co. of Detroit. EAGER can check the entire electrical system of a car against engineering specifications through programming with the use of 35 mm film and a bank of photocells.

A word description of the test to be performed is projected on a glass screen to enable the operator to conduct the test from the driver's position in the car, see Figure 1. Light from one half of the projector beam passes through a dot pattern on the film, Figure 2, and is shunted through a prism onto selection matrices—silicon photocells—which feed into the transistor-diode decoding logic. The decode logic feeds directly to the printer and timer circuits and to relays in the shunt circuit of a servoindicating meter. The meter face is mounted just below the screen. Thus the photocells tell the equipment what test is to be performed and automatically set delay cycles, amperage or voltage range, and other criteria for the test to be performed (see Figure 3).

FIG. 2. Typical frame from projector film shows binary coded test program (at right) which is read by silicon photocells.



When the operator presses the test system start button, instructions are flashed on the screen. The film frame projects the specification limits for the test so that they are adjacent to the meter scale.

If the operator is instructed to start the car, he does so. The coding device on the film strip activates wiring controls which measure the load placed on the battery by the starter, together with other desired data. The inspector compares the indicated load to the specifications on the screen. He presses an "ok" or a "reject" button on the hand control unit to record the test result on a printed tape. This automatically brings the next inspection step into operation. The machine measures performance in terms of the current or voltage span, the battery load, and the wiring and insulation resistances. A new model of the EAGER is being built which will accept or reject individual tests automatically to eliminate possible judgment errors by the operator.

About 50 tests are currently programmed and being performed by EAGER. It requires 12 to 15 min to perform all of them according to

TO THE ENGINEER

who can't tolerate a lapse of memory

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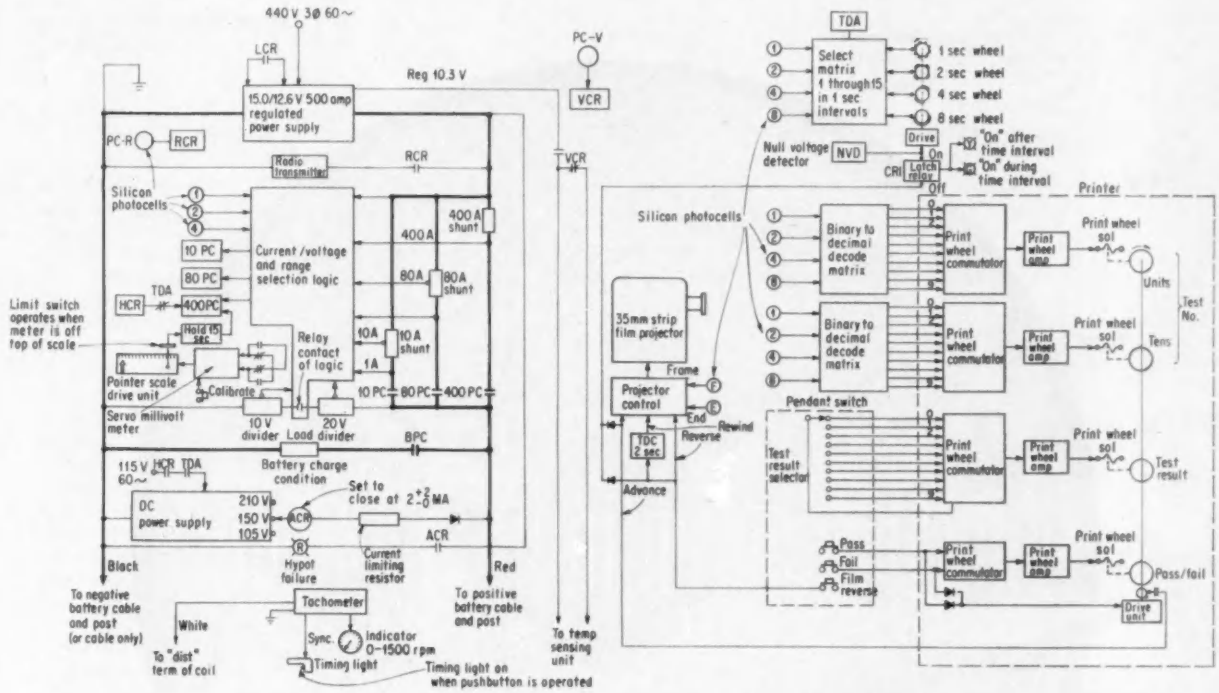


FIG. 3. Photocells read film codes to set up printer, meter ranges, and test circuits automatically. Projector is controlled by operator.

Lincoln engineers who developed the concept of the device. With portable equipment, comparable testing would take several hours, but many of these tests have never been performed before on a production basis. Five simple connections attach the machine to the car at battery and distributor.

The operator commands full control of the 35-mm projector and film. A reverse button moves the film back a frame so a test can be repeated. If the reverse button is depressed for 5 sec or more, the film rewinds to the start of the strip. The dot pattern on the film centers the frame on the screen and is so arranged that the machine automatically stops at the end of the film strip. The circuitry is interlocked so that loss of the film disconnects the testing function.

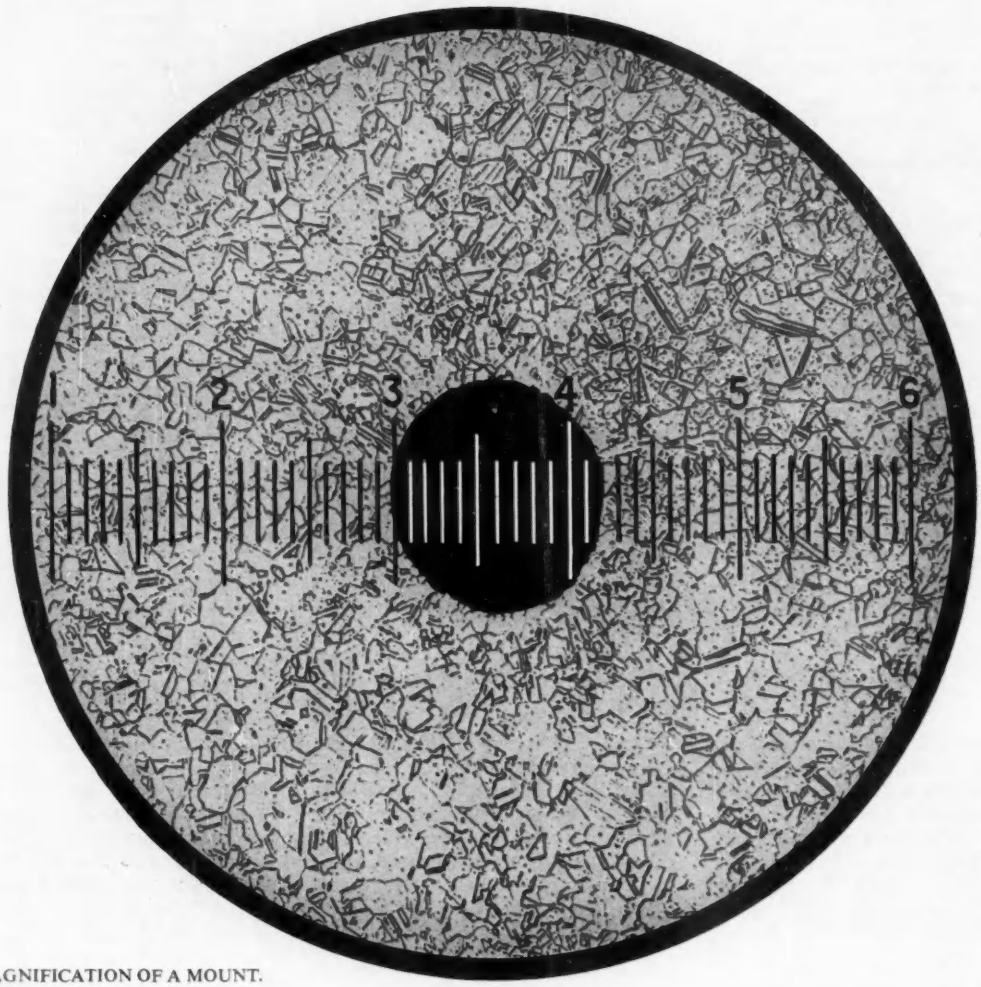
2. *Missile Checker Shows Percent of Tolerance Used*

ALEC DOIG, De Havilland Aircraft Co., Ltd., Hatfield, England

ACORN, an automatic checkout and recording equipment for missile electrical systems, simplifies the tester's job by displaying how much of the allowable tolerance on the selected input parameter has been utilized. The digital display shows the deviation of the measured parameter from its specified nominal value as a percentage of the assigned tolerance. This eliminates the normal conversion to tolerance values required in conventional checkout equipments which display actual measured voltages, currents, and frequencies.

The principal used in ACORN is simple. As shown in Figure 1, up to 300 test points are led into normalizing or scaling units. The output of each normalizer is a voltage corresponding to the deviation of the measured variable from its nominal value. A separate test routine selector programs the selection order of the input variables. Programming is subdivided into four main routines, each covering 88 channels. The main routines can be further subdivided into eight minor routines, each comprising continuous blocks of channels already programmed in the main routine. Test routines are initiated by dialing a three-digit code or by an external timer to give a continuous step-by-step run-through of the test points. Manual intervention allows initiation of a single test by inhibiting the routine until the end of the single test.

The tolerance utilization is deter-



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mined for each test point by standardizing the normalizer output currents so that all deviations lie between 0 and 50 microamp. This standard current range from a selected normalizer is compared with the output of a 100-step bidirectional staircase waveform generator. Each waveform step represents $\frac{1}{10}$th of the normalized deviation current of the input parameter from its specified nominal value. Thus 10 steps of the current generator from its midpoint represent the parameter's maximum acceptable deviation. Tolerance determination is then a matter of determining the count within the staircase generator. A dc chopper amplifier detects parity between the deviation current and the generator current. With inputs to the amplifier greater than $\frac{1}{4}$ of one step, the amplifier drives the bidirectional generator to reduce this difference to less than $\frac{1}{4}$ of one step. When achieved, the clock circuit driving the generator is inhibited.

Readout of the decimal state of the generator then provides the tolerance utilization of that test parameter directly. Neon character tubes indicate the sign of the tolerance utilization and the amount in a two-digit display. When the value is the nominal specified, the display reads 0.0. Variations between plus or minus five times the parameter deviation are displayed as readings between minus 5.0 and plus 5.0. Two lamps provide the PASS/FAIL indication. The FAIL lamp lights on the ninth generator step when the input parameter is greater the 0.9 times its specified tolerance from the nominal.

The generator decimal output is also serialized to give a printout record on a solenoid operated typewriter. On test routines the typewriter records the starting time of the routine and the test routine code number, followed by the channel numbers and the test results at a rate of one channel a second. On single test operation the typewriter records the start time of the test and the channel code number, and on completion of the test, the test result. Off-limit results are printed in red.

The equipment can be operated either from a control panel on the main cabinet unit, housing the programming panels, input normalizers, memory stores, and staircase generator, or from a small remote control console carrying the test result display and dialing unit. For small space uses tests can be controlled from a portable box.

FIG. 1. Simplified block diagram of ACORN checkout system with logic for tolerance utilization display shown shaded.

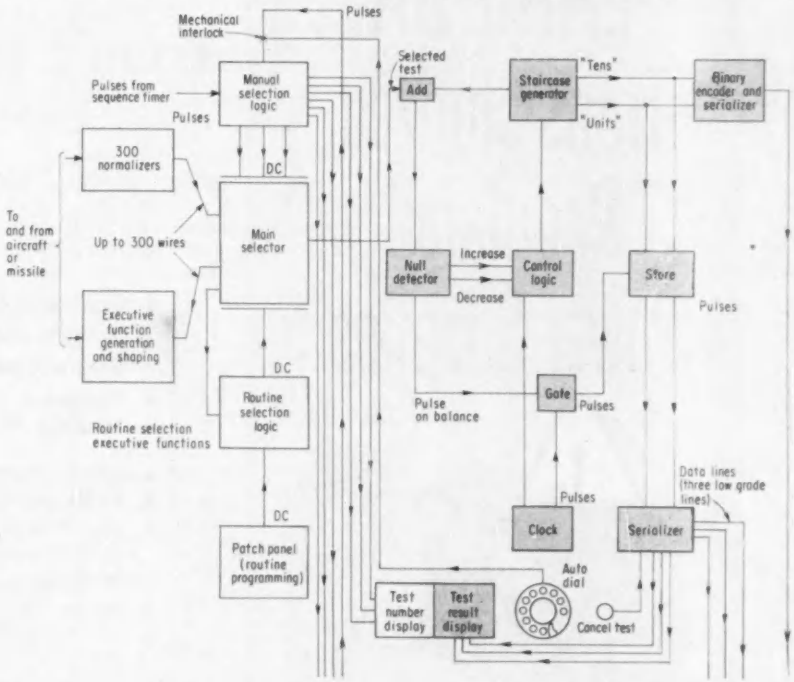
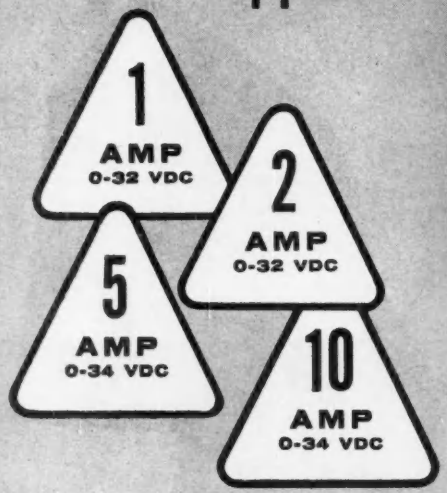


FIG. 2. Main cabinet of De Havilland's ACORN system. Test routines are programmed on patch panels at bottom.

LAMBDA
Transistorized Regulated Power Supplies



- **Convection cooled—no internal blowers to wear out.**
- **Guaranteed for a full 5 years.**
- **Compact. 1, 2, and 5 Amp only 3½" high, 10 Amp 7" high.**
- Ambient temperature 50°C.
- Excess ambient thermal protection.
- Special, high purity foil, hermetically sealed long-life electrolytic capacitors.
- Hermetically sealed transformer designed to MIL-T-27A.
- Remote sensing and DC vernier.

CONDENSED DATA ON LT SERIES

LT 1095M (with meters)	0-32 VDC, 0-1 AMP	$315
LT 2095M (with meters)	0-32 VDC, 0-2 AMP	395
LT 1095 (without meters)	0-32 VDC, 0-1 AMP	285
LT 2095 (without meters)	0-32 VDC, 0-2 AMP	365

MODEL	VOLTAGE BANDS
LT 1095, LT 1095M	0-8, 8-16, 16-24, 24-32
LT 2095, LT 2095M	0-8, 8-16, 16-24, 24-32

Regulation: Line: Better than 0.15 per cent or 20 millivolts (whichever is greater). For input variations from 105-125 VAC. **Load:** Better than 0.15 per cent or 20 millivolts (whichever is greater). For load variations from 0 to full load.

AC Input: 105-125 VAC, 50-400 CPS.

Ripple and Noise: Less than 1 millivolt rms.

Ambient Temperature: 50°C—continuous duty.

Remote DC Vernier: Provision for remote operation of DC Vernier.

Remote Sensing: Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

Size:
LT 1095 3½" H x 19" W x 14⅜" D
LT 2095 3½" H x 19" W x 14⅜" D

CONDENSED DATA ON LA SERIES

LA 50-03AM (with meters)	0-34 VDC, 0- 5 AMP	$425
LA100-03AM (with meters)	0-34 VDC, 0-10 AMP	540
LA 50-03A (without meters)	0-34 VDC, 0- 5 AMP	395
LA100-03A (without meters)	0-34 VDC, 0-10 AMP	510

MODEL	VOLTAGE STEPS
LA 50-03A, LA 50-03AM	— 2, 4, 8, 16 and 0-4 volt vernier
LA100-03A, LA100-03AM	— 2, 4, 8, 16 and 0-4 volt vernier

Regulation: Line: Better than 0.15 per cent or 20 millivolts (whichever is greater). For input variations from 100-130 VAC. **Load:** Better than 0.15 per cent or 20 millivolts (whichever is greater). For load variations from 0 to full load.

AC Input: 100-130 VAC, 60 ± 0.3 cycle. This frequency band amply covers standard commercial power lines in the United States and Canada.

Ripple and Noise: Less than 1 millivolt rms.

Ambient Temperature: 50°C—continuous duty.

Remote DC Vernier: Provision for remote operation of DC Vernier.

Remote Sensing: Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

Size:
LA 50-03A 3½"H x 19" W x 14⅜" D
LA100-03A 7" H x 19" W x 14⅜" D

LA 118

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Argus' Pegboard Stores Program In Ferrite Plugs

M. W. GRIBBLE, Ferranti Ltd.
Manchester, England

The prime criterion for process control computers is extreme reliability rather than flexible programming. The fact that programs are infrequently changed in process computers (also true for microprogrammed instructions and interrupt subroutines in data processing systems) allows the use of nonerasable fast-access semipermanent stores. Ferranti's "Argus" transistorized process control computer uses such a program store.

Argus is a fixed point binary machine with a modified two-address order code of over 50 instructions using 12 or 24-bit word lengths. It includes six accumulators, of which three can be used as modifiers. Serial-parallel operation gives an addition time of 20 microsec for 12-bit numbers, including ½-microsec access time, and multiplication in 100 microsec.

Up to 1,024 word blocks can be programmed on a unique noncontacting semipermanent mutual inductance plugboard. The program cannot be accidentally erased or written over. The basis of the system is that the mutual inductance between two pairs of parallel conductors in parallel planes is zero if the conductor-pairs cross at right angles. But this is only true in a medium of uniform permeability. If a small ferrite rod is inserted in the rectangle bounded by the intersection of the two conductor pairs (see Figure 1) an emf is induced in one of the pairs of conductors when a current pulse is applied to the other pair.

Figure 2 shows the form of this storage system used on Argus. Sixteen 20 x 15 in. printed circuit trays can each store 64 instructions of 24 bits. Drive circuits using two rows of eight channels are printed on the underside of each card. Diode matrices decode the drive pulses into 64 drive loops running left to right on each card.

Visible on the top of each card at right angles to the drive circuits is a 27 x 64 printed matrix. Plug holes are located at each intersection between the top and bottom patterns. Each of the 64 steps is programmed by inserting 1-mm ferrite plugs. In the 24-bit word 12 plugs give the address, three specify the accumulator, six are for function description, and three for modifiers.

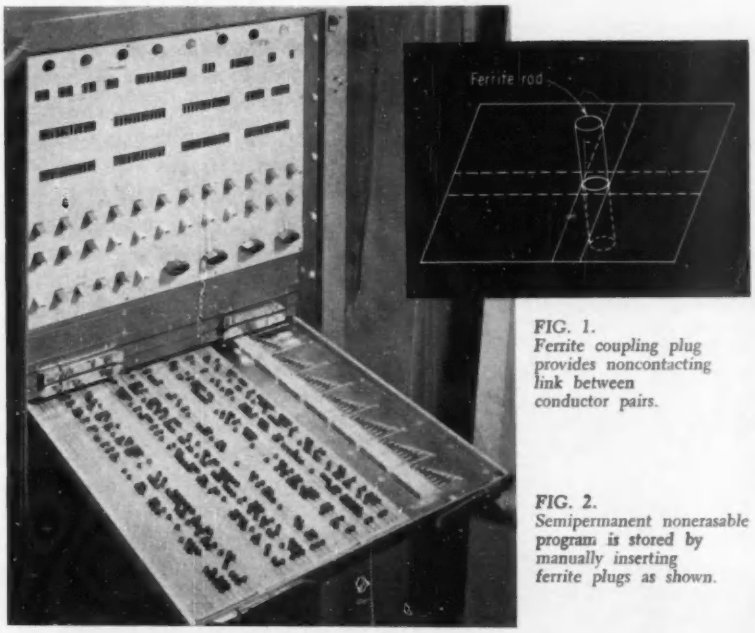
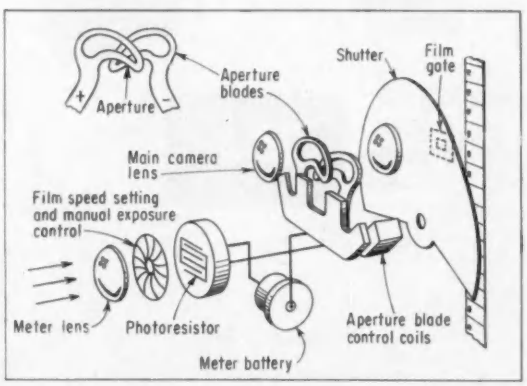


FIG. 1.
Ferrite coupling plug provides noncontacting link between conductor pairs.

FIG. 2.
Semipermanent nonerasable program is stored by manually inserting ferrite plugs as shown.

Meter Movement Sets Camera Exposure



The new "Leicina" movie camera by Leitz of Wetzlar, W. Germany, uses an adaptation of a moving-coil ammeter to control film exposure automatically. Light falling on a photoresistor alters its resistance to change the current passing through a moving-coil instrument system. Two aperture blades are attached to two moving coils. Hence the position of the aperture blades varies in proportion to the amount of light entering the exposure control lens.

The iris diaphragm between the meter lens (exposure control lens) and the photoresistor is used for setting for film speeds between ASA 6 and 400. An aperture scale and meter pointer appear in the viewfinder. An overdrive device is provided for making manual adjustment at any time. When a manual setting is made, the exposure meter accepts this as the reference point, varying the exposure around this value as subject brightness increases or decreases.

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CIRCLE 124 ON READER SERVICE CARD

Differential Cam Follower Controls Pneumatic-Hydraulic Actuator

A. M. FUCHS and K. ZEUNER
Boonshaft & Fuchs, Inc.

Much of industrial control is rooted in 3 to 15-psi pneumatic hardware of high accuracy and reliability. But low response speed, inadequate position resolution, and excessive reaction to changes in load force may be encountered in such systems as force levels, strokes, and actuator speed requirements increase.

A pneumatic-hydraulic positioning system has been designed which provides high power-level positioning capability for pneumatic control systems, Figure 1. The actuator is a complete closed-loop system in which the feedback signal is generated by a position-to-pressure converter which combines flexibility with high accuracy, resolution, and speed-of-response.

The position-to-pressure converter, Figure 2, uses a cam to convert the cylinder stroke to a standard motion of about 1 in. The cam permits direct application of the converter to any stroke length and permits generation of nonlinear functions relating output position to the input signal for the pneumatic-hydraulic positioner.

The 1-in. cam output is followed by a pair of spring connected arms whose separation is proportional to the dimension across the cam. The pair of arms eliminates almost all of the effect on the converter output of spurious sidewise motions of the cam.

One arm supports a nozzle which is connected in turn to the air supply line through a fixed orifice. It also carries a plate to which the flapper is connected. The other arm is spring connected to the flapper. A force balance is established between the spring tension and the pressure of the air in the nozzle on the flapper.

Thus as the cam dimension increases, the arm separation increases, the spring tension increases, and the pressure in the nozzle increases until a force balance is achieved between the spring force and the pneumatic force. The pressure developed is a linear function of force. At the force levels of ½ to 1 lb used, vibration is largely eliminated because of the light weight of the parts and because of their orientation in line with the output motion.

Because the volumes are small and the parts light, this converter has a very high frequency response (over 25 cps). It has demonstrated a resolution of over 1 part in 2,000. This high resolution is essential to stable overall positioning and to realizing the full potential of the actuator.

Error (difference between the input 3 to 15-psi command and the feedback signal generated by the converter) is sensed by a pair of diaphragms. The diaphragms are flexure connected to the input arm of a force-balanced hydraulic amplifier. As in the converter the error sensor is a force balance system in which plus or minus 15 lb is available. The force-balanced hydraulic valve requires less than ½ lb for full output. Most of this input force is linearly related to output flow. In the null position it introduces no error, and at constant output velocity only a small amount to velocity errors.

Two stages of hydraulic amplification are included. Units with 5, 10, and 20 gpm output flow capability (3,000 psi oil supply, 1,000 psi valve drop at rated flows) have been built, and designs are available to 400 gpm (or approximately 750 hp).

The over-all frequency response is typically down 3 db and lagging 90 deg at 3 to 7 cps. System linearity is approximately 2 percent and the resolution is 1 part in 2,000 of full scale. Load sensitivity is less than 0.1 percent for load changes of 50 percent of full load. Output velocities can be as high as 10 in. per sec and output force is not limited by the actuator system.

Saturation in the control loop occurs only in the output stage and is a velocity limiting characteristic. All of the other equipment is in its linear range when the output is not velocity limited. This feature simplifies the problem of simulating this actuator since the response is the same for large valve motions as for small ones.

Pneumatic-hydraulic actuators can upgrade the positioning capability of key control valves to derive the full benefit from computer-control.

FIG. 1. Pneumatic-hydraulic actuator for process control valves uses unique position-to-pressure converter.

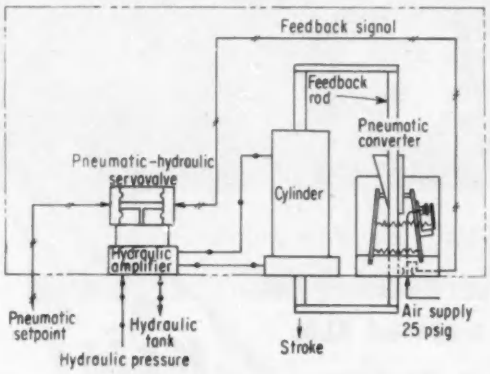
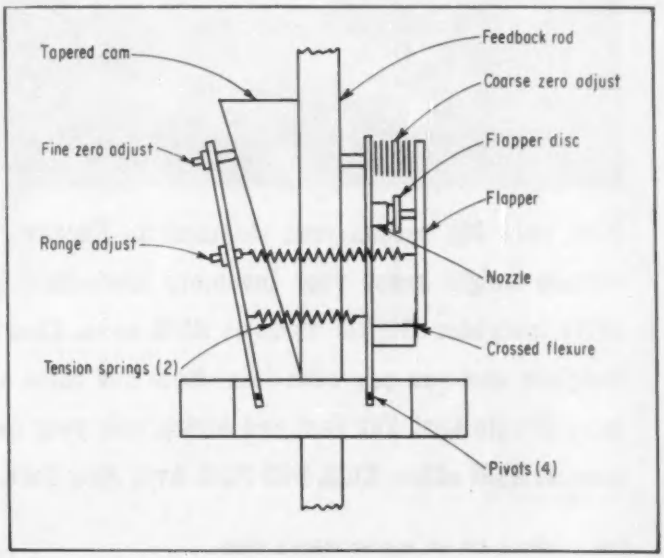
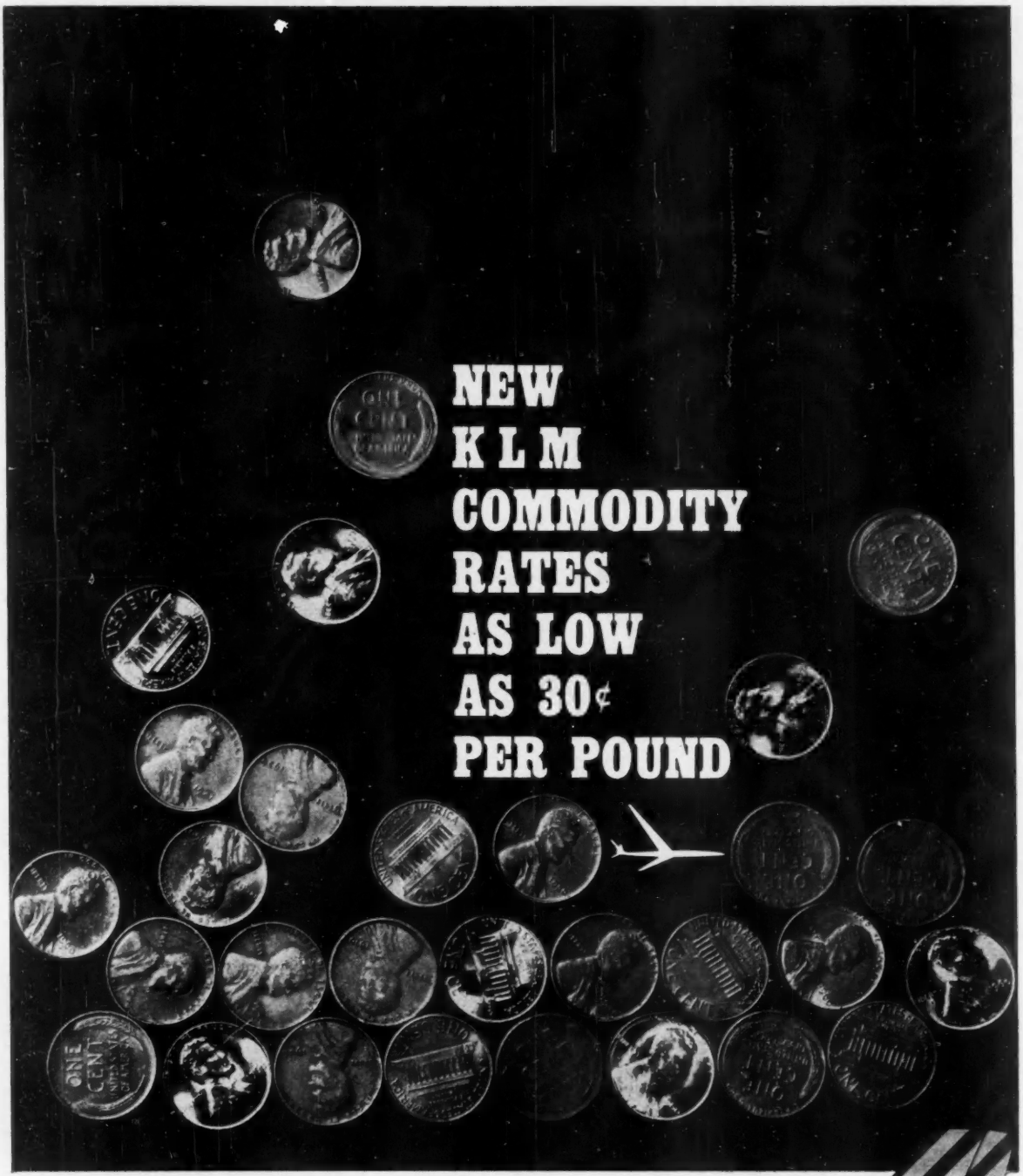


FIG. 2. Converter has differential follower action on feedback cam to eliminate effects of vibration of actuator.





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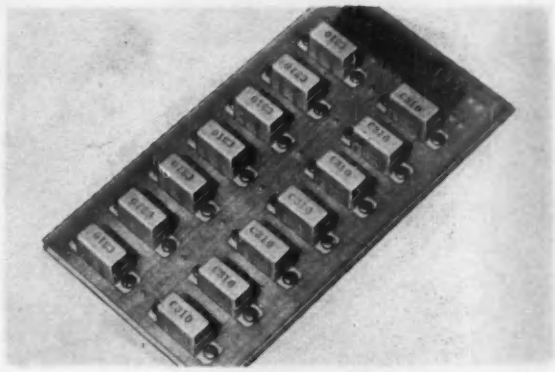
NEW PRODUCTS

VOLTAGE DIVIDER offers 15-bit accuracy.

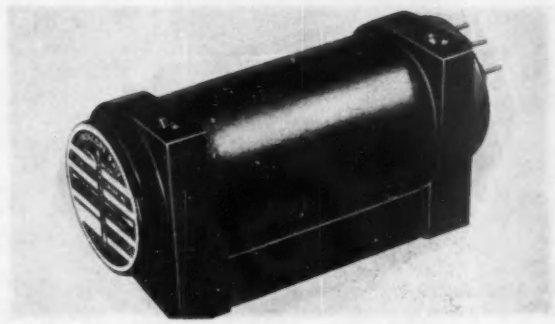


This rugged Model RVDM-305 relay-operated voltage divider features an absolute accuracy and resolution of within 0.003 percent over its full service life. The unit incorporates premium JRL precision resistors and carefully chosen relays. Its design reduces the disturbing effects of leakage currents, contact resistance, and contact potential to provide a generous margin of safety under all conditions. A very short response time (under 15 millisec) makes the device suitable for keyboard or high speed paper tape or card operation.

All components are accessible and mounted on a heavy glass-epoxy card 3¾ in. wide by 7¼ in. long.–Julie Research Laboratories, Inc., New York, N. Y.

Circle No. 309 on reply card

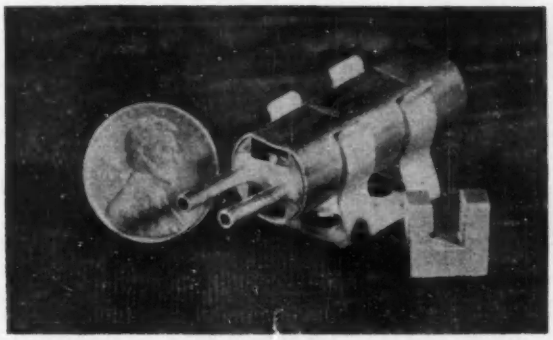
NEW RATE GYRO uses 1½ watts for spin.

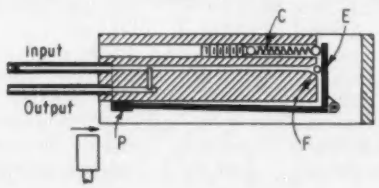


Called the Talisman, this new subminiature rate gyro offers some interesting design improvements. Its damping is entirely disassociated from the volumetric compensator so that density changes in the damping fluid do not affect performance. As temperature ranges from minus 54 deg C to plus 84 deg C, the change in damping is only from 0.5 to 0.9 times critical.

Total maximum power consumption of its tiny spin motor is only 1¼ watts as compared to 3¼-4¼ watts for comparable gyros. Unit operates on 26-volt, 400-cycle power.–Instrument Div., Lear Inc., Grand Rapids, Mich.

Circle No. 310 on reply card





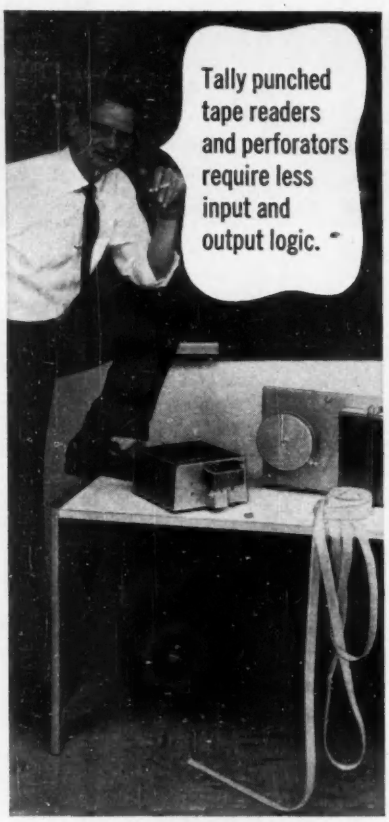
TINY AIR SWITCH weighs under 2 oz.

Just 1½ in. long by ½ in. in diam, this miniature air switch may be used to replace electrically operated switching devices where convenience or safety warrants the change. Designed especially for use in pneumatic circuits where only a very low actuating force is available, the switch uses a simple magnet for actuation.

The cross-sectional sketch below the photo shows the unit in its deenergized position. Bleed port *F* is held open by the action of the compression spring C on the crank arm *E*. When the magnet *M* attached to some moving member passes close to crank arm *P*, the arm pivots compressing spring *C*, closing bleed port *F*, and causing the output pressure to increase until it equals the input pressure.

As a limit or proximity device the switch can be used to actuate remote position indicators or counters. It can be coupled directly to relay valves in cutoff and sequential circuitry. It can also be used for the remote indication of valve stem position in process control systems. Available from stock, unit sells for approximately $25.–Associated Control Equipment, Inc., Coraopolis, Pa.

Circle No. 311 on reply card



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NEW PRODUCTS

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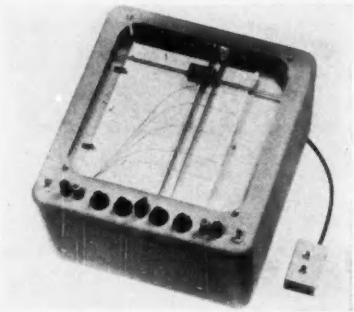
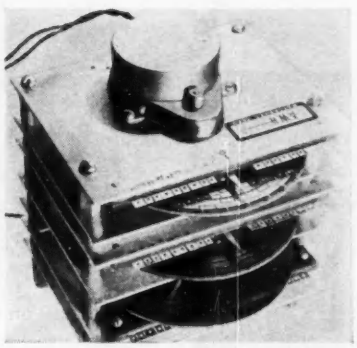


X-Y RECORDER

An electric pen lift allows this X-Y recorder to plot points, trace family curves, and perfom rapid nonrecording pen indexing. The recorder can be tied into the test circuitry or operated with a manual control box. For easy loading the pen is automatically indexed away from the chart area. Each axis has its own power supply, attenuator, and zero control. Either axis may use amplifiers available with 10 mv/in. and 1 mv/in. sensitivity. Pen speed for both axes is 7½ ips with error of only ½ percent. Prices: $670-770.—Houston Instrument Corp., Houston, Tex.

Circle No. 312 on reply card



GENERATES BINARY CODE

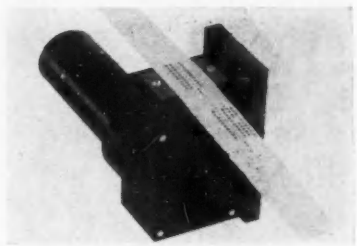
This device converts analog data in the form of shaft position angles into a digital output represented by a coded pattern of electric signals. By changing the drive systems, timing motors, or accessory equipment, the generator can be adapted to many requirements. Units now in production are basically binary time coded. All models are available open, closed, or sealed; with digital or clock face readout; and with manual or electric adjustment. Prices start at $100.—A. W. Haydon Co., Waterbury, Conn.

Circle No. 313 on reply card

LOGIC DISPLAYS

Alphanumeric computer and data display applications for recently announced electroluminescent panels have now been demonstrated. The panels are suitable for low cost visual readout and can also perform memory functions in digital systems. Among the devices that have been made are: a bistable memory plane, binary to decimal and decimal to binary converters, and both OR and AND logic elements.—Sylvania Electric Products, Inc., Sub. of General Telephone & Electronics Corp., New York, N. Y.

Circle No. 314 on reply card



OPTICAL READING HEAD

For systems using perforated tape as the memory, this optical reading head is said to provide improved signal to noise ratio. Including time base, reading speed is 10,000 characters per sec. A 10-volt tungsten lamp requiring 6-7 volts is the light source. Dual beam focusing, concident circuits for signal comparison, and a mechanical clock offset hole system can be incorporated into the unit. Manufacturers report successful operation in computer applications. Base price: about $1,200.—Par Products Corp., Santa Monica, Calif.

Circle No. 315 on reply card

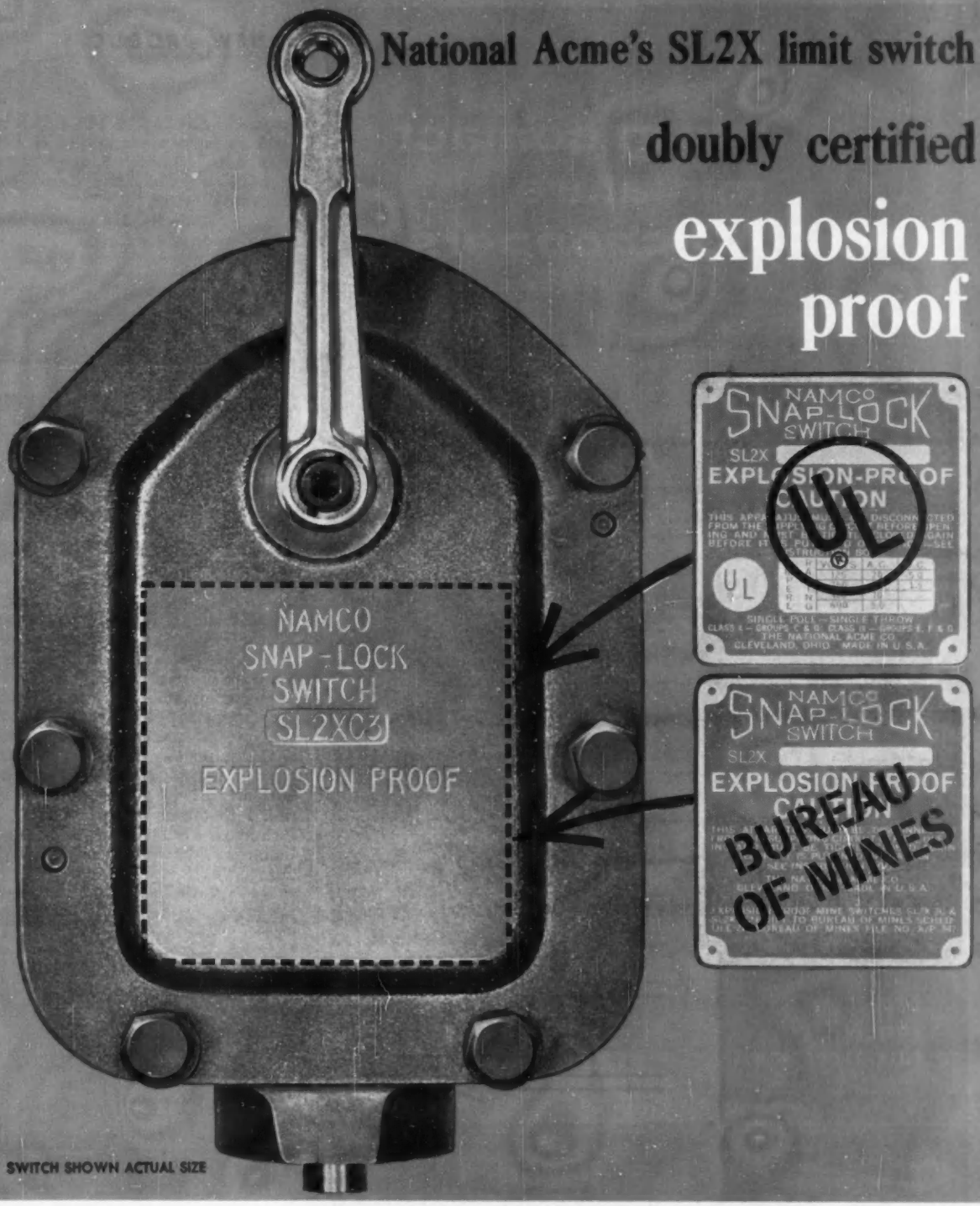
TAPE-TO-CARD CONVERTER

Basically a block tape reader and decoder, this completely solid state system consists of the manufacturer's Type 55 tape-to-card converter and a standard IBM summary punch. A block tape reader, a decoder, storage matrix, interlocking control relays, necessary manual controls, and power supply make up the functional components. Speed is 100 cards per min, and block length is 22-44 digits, 5-8

National Acme's SL2X limit switch

doubly certified

explosion proof



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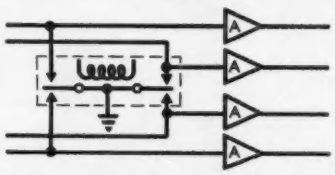

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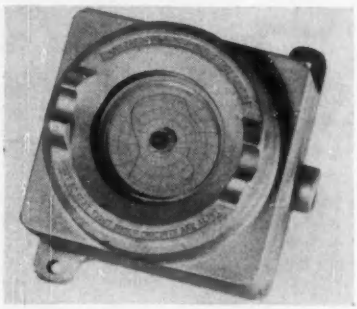
NEW PRODUCTS

channels. Size is 33 x 24.5 x 53.5 in. with an input power needed of 105-120 volts, 60-cycle, 8 amp. Cost: $14,500.—Telecomputing Corp., No. Hollywood, Calif.

Circle No. 316 on reply card



MINIATURE RECORDER

So small that nine can be mounted in 1 sq ft of panel space, this recorder is able to record any variable that can be converted into an electric signal. Inputs as low as 10 microamps are fed without amplification directly to the meter movement. A stylus records the input on a 3-in. diam chart of pressure sensitive paper. Principal applications are said to be with laboratory and portable equipment that cannot use recorders of conventional size. Price: between $150 and $200.—Instrument Div., Thomas A. Edison Industries, McGraw-Edison Co., W. Orange, N. J.

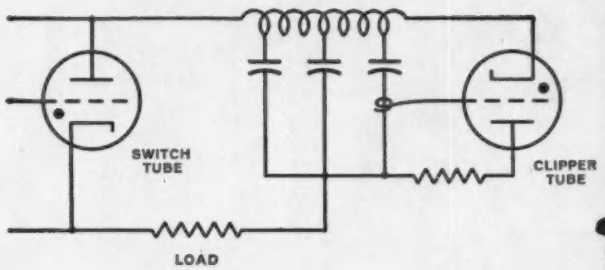
Circle No. 317 on reply card

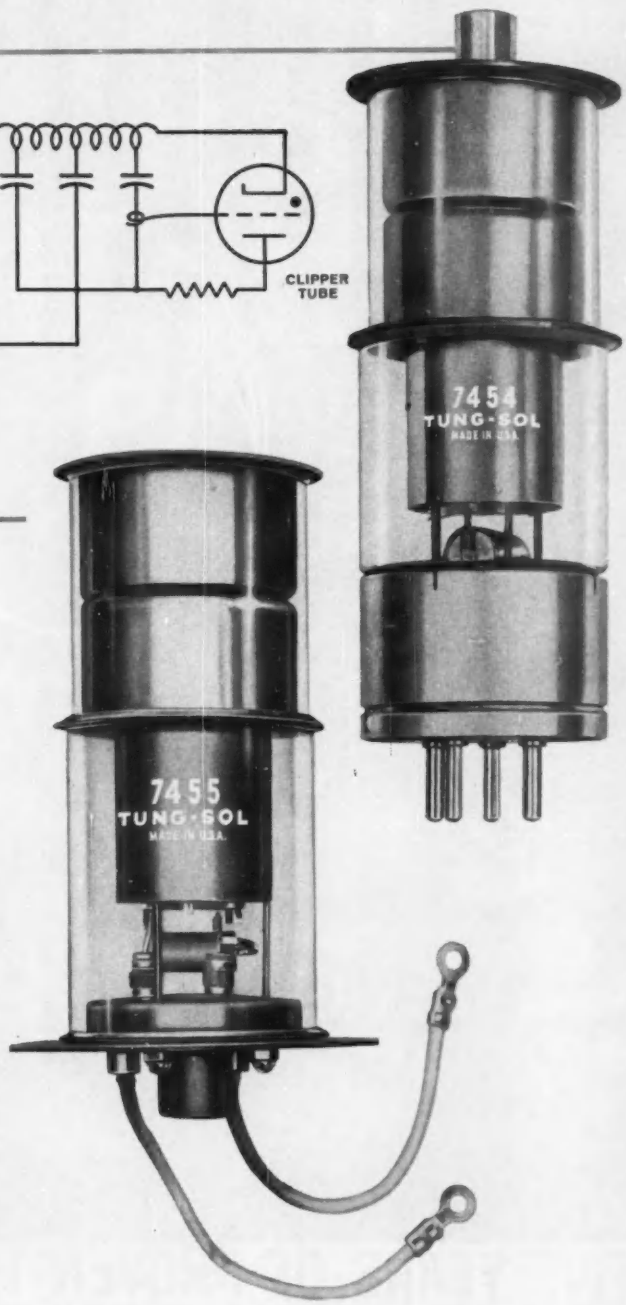
10-KEY DATA INPUT

No outside technical assistance is needed to integrate this direct entry data input device into any system. The unit shown has five control keys, but up to 30 can be accommodated; a 10-key keyboard is standard. Indicator lights are available. It is applicable to remote operations and can be

End-of-line clipper

Clipper tube is connected across the far end of the pulse-forming network in series with a resistive load whose value approximates the network impedance. When the clipper tube is triggered, the pulse-forming network terminates in its characteristic impedance thereby reducing the inverse voltage to zero.





Positive protection against destructive voltages with Tung-Sol Clipper Thyratrons

Line-type radar modulators require clipper protection against excess inverse voltages, which can destroy costly components and increase equipment downtime. Clippers also perform valuable circuit service by regulating pulse amplitudes and reducing switch tube loading.

But until Tung-Sol developed these high-reliability hydrogen-filled clipper triodes previously used clipping devices brought some serious disadvantages to the job.

Now, however, you can be sure of *perfect* clipping action when you design Tung-Sol clippers into your equipment. More rugged and less costly than solid state devices, more efficient with a much lower dynamic impedance than vacuum clippers, and faster acting and more resistant to arc-back than gas diodes, the new Tung-Sol thyratron clippers are designed and built to deliver uncompromised performance.

The low "firing" voltage and the ability to carry large peak currents make these hydrogen clipper thyratrons ideal for this application. These tubes also feature hydrogen reservoirs which promote long life by providing an automatic mechanism for replenishing hydrogen lost by "cleanup".

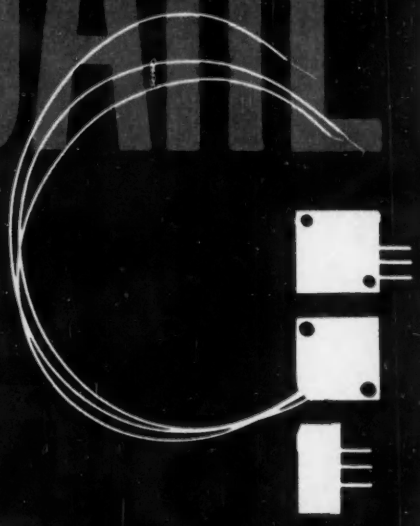
Circuit requirements are simple whether the Tung-Sol thyratrons are used as "end of the line" clippers, "across switch" clippers or "tail biters".

Write for complete technical details on the new 7454 and 7455 Clipper Thyratrons. Tung-Sol Electric Inc., Newark 4, N. J. TWX:NK193.

TUNG-SOL

Technical information available through ATLANTA, GA.; COLUMBUS, OHIO; CULVER CITY, CALIF.; DALLAS, TEXAS; DENVER, COLO.; DETROIT, MICH.; IRVINGTON, N. J.; MELROSE PARK, ILL.; NEWARK, N. J.; PHILADELPHIA, PA.; SEATTLE, WASH. IN CANADA: ABBEY ELECTRONICS, TORONTO, ONT.

SQUARETRIM



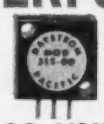
FIVE YEARS OF PROVEN TRIMMER PERFORMANCE

(ACTUAL SIZE)
SERIES 300

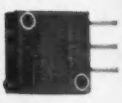
SERIES 301

SERIES 311

SERIES 313



SERIES 315
SERIES 316



THE ONLY SQUARE TRIMMING POTS WITH OVER 2,000,000 UNITS DELIVERED

Daystrom SQUARETRIM potentiometers may look like the many square configuration copies which have been flooding the industry in recent weeks, but they are different. This difference is in their outstanding performance, reliability and broad-line availability. Daystrom has had five years to develop, produce and field-prove the features of the SQUARETRIM potentiometers, so whatever features are important to your application, you can be sure that there is a Daystrom SQUARETRIM to meet your most exacting requirements.

The proof that Daystrom delivers what it promises can be found in over 2,000,000 Daystrom SQUARETRIM's which have been placed into customer operation since 1955. It costs no more to be sure, so when you are ready to order trimming potentiometers, contact your nearest Daystrom Representative or Distributor for immediate delivery. Or you may write the factory direct for Data File CE 1350-2.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
Archbald, Pennsylvania • CAnal 6-3300 (New York, N.Y.)

CIRCLE 132 ON READER SERVICE CARD

THERE ARE MORE DAYSTROM SQUARETRIM's IN THE FIELD TODAY THAN ALL OTHER SQUARE TRIMMING POTS COMBINED

Here's why...

Because engineers want to be sure of the basic design, more of them look to the originator of the square-shaped trimmers. They look to Daystrom when specifying this kind of potentiometer.

Because they want to be sure of performance and reliability, more designers look to Daystrom for their SQUARETRIM's. They know they can trust Daystrom specs. They appreciate the conservative ratings, and they have full confidence in the greater safety margin that such ratings afford. And they can be sure that Daystrom SQUARETRIM's will go on meeting application requirements with the same high reliability that has been proven by the 2,000,000 units that have seen field service over the past five years.

Because engineers want to be sure of availability, they like the convenience of doing business with two complete factory sales and stocking offices—one on each coast. They know that from these two factory offices and Daystrom's 23 representatives and many stocking distributors from coast to coast, they can expect to obtain the exact SQUARETRIM's to meet their needs. They know they are selecting from the broadest line of square-shaped trimming potentiometers available today when they specify the Daystrom SQUARETRIM line.

That is why more knowledgeable designers looking for trimming potentiometers specify Daystrom SQUARETRIM—they want the best...and the best is easiest to get.

For more information or a complete file listing the entire SQUARETRIM *line, contact your nearest Daystrom Representative or Distributor, or write the factory direct. Ask for Data File CE-1179-2.*

DAYSTROM

POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA

NEW PRODUCTS

used with punched or magnetic tape and cards. Price for the model shown: $245. Clary Electronics Div., Clary Corp., San Gabriel, Calif.

Circle No. 318 on reply card

PLUS . . .

(319) Facitape, a Swedish computer **accessory,** marketed in the U. S. by **North American Aviation Inc.,** Downey, Calif., has solid state components and uses unique capacitance readers to duplicate tape, read tape, or both. . . . (320) Priced at $633 per channel, this Model 3735 **electronic multiplier** from **Systron-Donner Corp.,** Concord, Calif., offers single quadrant multiplication and squaring with error of 0.01 percent. . . . (321) **F. L. Moseley Co.,** Pasadena, Calif., has announced a **transmissibility plotting system** that automatically plots ratios of two voltages against a third.

Circle Nos. 319, 320, or 321 on reply card

RESEARCH, TEST & DEVELOPMENT

PROGRAMMED RELAY TESTER

By immediately presenting relay test results visually and recording them on a printer, this testing unit allows correction of process deviations before too much scrap is generated. The system converts absolute measurements into cellular form. Eight parameters are measured, and accept or reject information is presented by the readout. A self-contained unit, the tester is programmed by standard punched tape which directs the type and sequence of tests. Performance limits are inserted on punched cards. The device can also be adapted to test other components.—General Electric Co., Schenectady, N. Y.

Circle No. 322 on reply card

TESTS MODULES

The completely self-contained Model 1300 B is designed to test the manufacturer's complete line of transistorized digital system modules. The tester provides all standard signals for verifying correct operation, including three standardized waveforms; all supply voltages; variable loads and check of margin, sensitivity, and frequency. No oscilloscope is needed for most checks since single-pulse generator and output monitor meter are used. Price: $995.—Navigation Computer Corp., Philadelphia, Pa.

Circle No. 323 on reply card

DATA SIMULATOR

Electric signals simulate high precision synchros, resolvers, generators, and other transducers in this device called a Dator data simulator. It is claimed to test many types of analog systems with an accuracy greater than most transducers. The illustrated unit simulates a 26-volt, three-wire synchro transmitter at increments of 5 deg from 0 through 360 deg. For simple operation there is one-knob control. Price: $285.—Angler Industries, Metuchen, N. J.

Circle No. 324 on reply card

WIRING ANALYZER

Up to 6,000 circuit assemblies are checked for current continuity and

. . . her conscientious workmanship watches over
RECORDING CHART RELIABILITY

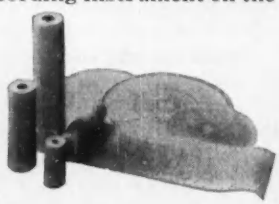
"Dish" occurs at the core end of a roll chart wound with incorrect tension. It means loose winding — and can lead to trouble.

Lois Deinhart, one of GC's experienced rewind operators, helps prevent this trouble from ever occurring. Here she is operating one of a battery of high speed precision rewind machines that roll strip charts to the exact length and tension required. Inspection by Lois and other skilled operators allows only perfect rolls to pass for shipment.

Because of special equipment and specially talented people, GC has become the world's largest manufacturer of recording charts—producing rolls, for instance, for virtually every make of strip chart recording instrument on the market. Over 70 different types of cores are available, each suited to the requirements of a specific instrument. End of roll indicators can be provided for visual, mechanical or electronic alarms.

GC's stock catalog lists over 15,000 different types of circular, strip and rectangular charts. We also design and produce special purpose charts to fit your most exacting needs.

More than 5,000 chart users have come to rely on GC Recording Charts for accurate, dependable performance—chart after chart—year after year. In fact, GC Charts must be good to sell so well for so long. Try them yourself! Let us send you our complete Stock List, and sample charts for one of your instruments.



RECORDING CHARTS

Distributed by:
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GRAPHIC CONTROLS CORPORATION

EVERY USER OF OSCILLOGRAPHS should have this FREE PORTFOLIO

This portfolio, yours for the asking, tells eight ways you'll benefit by standardizing on GC direct-writing charts. It holds a sheaf of samples to give you the "feel" of the ultra-smooth, specially milled paper on which GC Charts are printed. On the back is a handy guide for ordering the GC direct-writing charts that will meet your needs.

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BUFFALO 10, NEW YORK

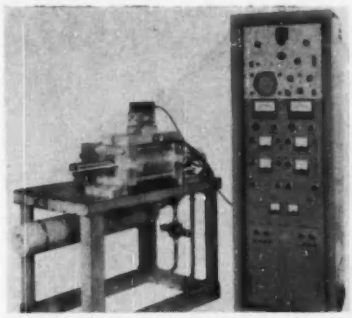
Please send me your new portfolio of information and samples of GC direct-writing charts. No charge or obligation, of course.

Name_____
Firm_____
Address_____
City_____ State_____

NEW PRODUCTS

leakage on this automatic wiring analyzer. IBM cards corresponding to the circuit being tested control the tests. Each circuit requires a card, with 60 cards processed every minute. Cards are automatically classified as to type of circuit failure after completing their test cycle. Leakage failures are pinpointed by recycling the trouble cards. Leakage locator lights indicate exactly which wires are faulty in the circuit.—Hughes Aircraft Co., Culver City, Calif.

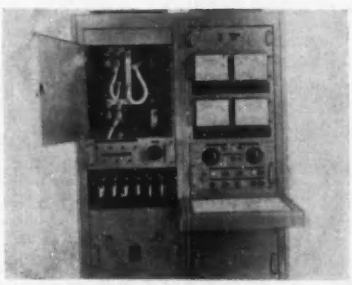
Circle No. 325 on reply card



LOAD SIMULATOR

All the controls and instruments necesssary to perform test dynamic loading and stroking on devices having force vs displacement or force vs velocity characteristics are contained in this Model 550 control console. Both external programming by tape and cyclic programming through a function generator are possible. Load and position can be read and controlled. Dynamic readings, made by oscilloscope, have an error of only ±3 percent. Under static conditions error is only ±1 percent.—Pegasus Laboratories, Inc., Berkley, Mich.

Circle No. 326 on reply card

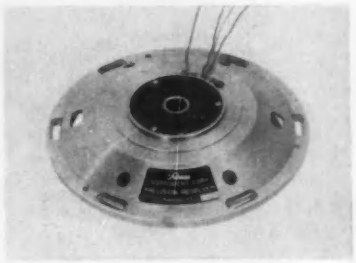


RECTIFIER TESTER

Shown above is the new Model 164, a 200-amp dynamic test set that can evaluate simultaneously the characteristics of four silicon rectifiers in a full wave circuit. Unit consists of two power supplies: a low voltage, high current supply for forward characteristics and a high voltage, low current supply for reverse characteristics. Simulation of actual operating conditions is achieved by switching the two on alternate half-cycles. Panel meters (1-percent error) indicate peak forward voltage drop, average forward current, reverse voltage, and average reverse current. Price: $11,525.—Wallson Associates, Inc., Elizabeth, N. J.

Circle No. 327 on reply card

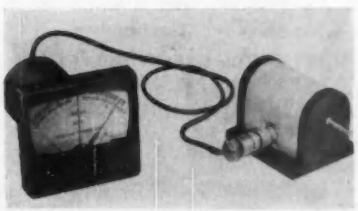
PRIMARY ELEMENTS & TRANSDUCERS



ACCURATE RESOLVER

Accuracy of 10 sec of arc is said to suit this pancake resolver for use in stable platforms of inertial guidance systems. Its repeatability is to within 2 sec. Integral bearing design allows direct gimbal mounting. Either the primary or secondary member can be rotated with the other member fixed. Beryllium or aluminum housings are available. — Reeves Instrument Corp., Sub. of Dynamics Corp. of America, Garden City, N. Y.

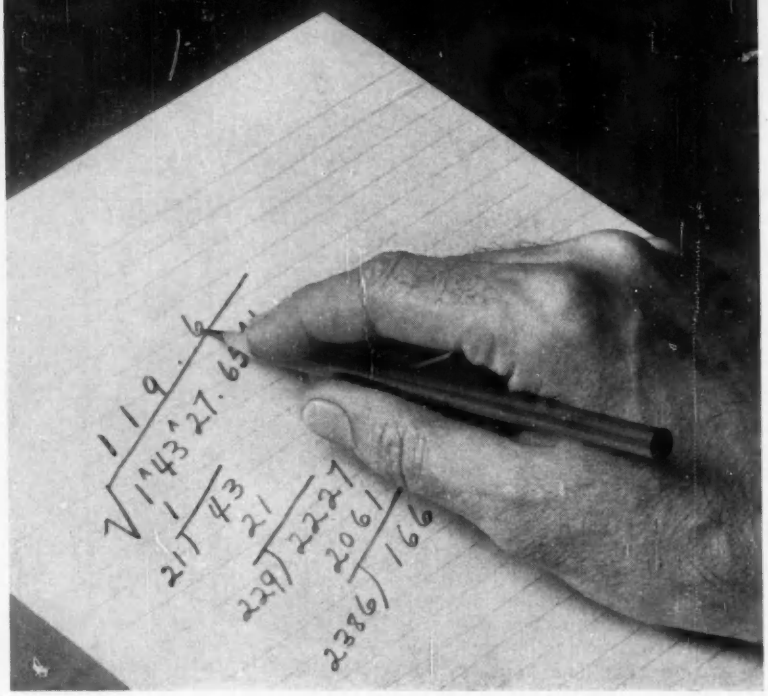
Circle No. 328 on reply card

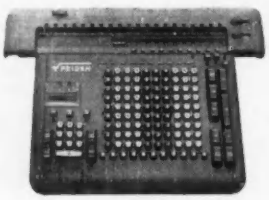


LINEAR TRANSDUCER

Available separately or in combination with a panel meter or meter relay, this transducer converts a linear position to a signal read on a meter, more simply and economically than a lvdt. The signal need not be amplified. The de-

Friden makes a desk calculator that does this automatically





The Friden Model SRW is the only calculator in the world that extracts square root at the touch of a key.

Because it does, a tedious, time-consuming job becomes as easy (and as quick) as entering the radicand, fixing the decimal point, reading the answer.

Because the time it saves generally belongs to high-priced people, the SRW will pay for itself even if used only a few times a day for square root. (The Model SRW is also a complete desk calculator in its own right, with all of Friden's time-saving features.)

Call your local Friden Representative for a no-obligation, ten-minute demonstration. Or write: Friden, Inc., San Leandro, California.

THIS IS PRACTIMATION: automation so hand-in-hand with practicality there can be no other word for it.

© 1961 FRIDEN, INC.

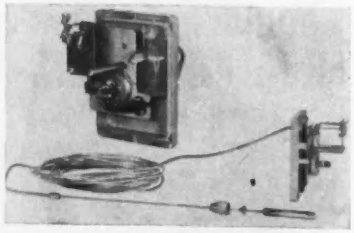
Friden

SALES, SERVICE AND INSTRUCTION THROUGHOUT THE U. S. AND WORLD

NEW PRODUCTS

vice is best suited to measuring deviations of a few thousandths of an inch from mechanical null. Meter calibration is one mark per in., accuracy is to within ±0.0002 in., and reproducibility is to within ±0.0001 in. Maximum readout speed is one per sec. Price: $95 for transducer with panel meter, $215 for transducer with continuous reading meter relay.—Assembly Products, Inc., Chesterland, Ohio.

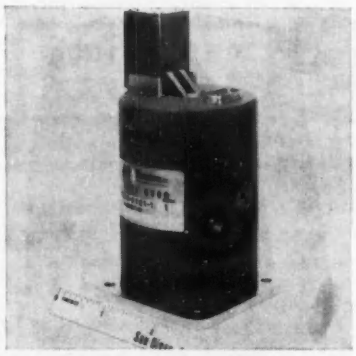
Circle No. 329 on reply card



MERCURY MEASUREMENT

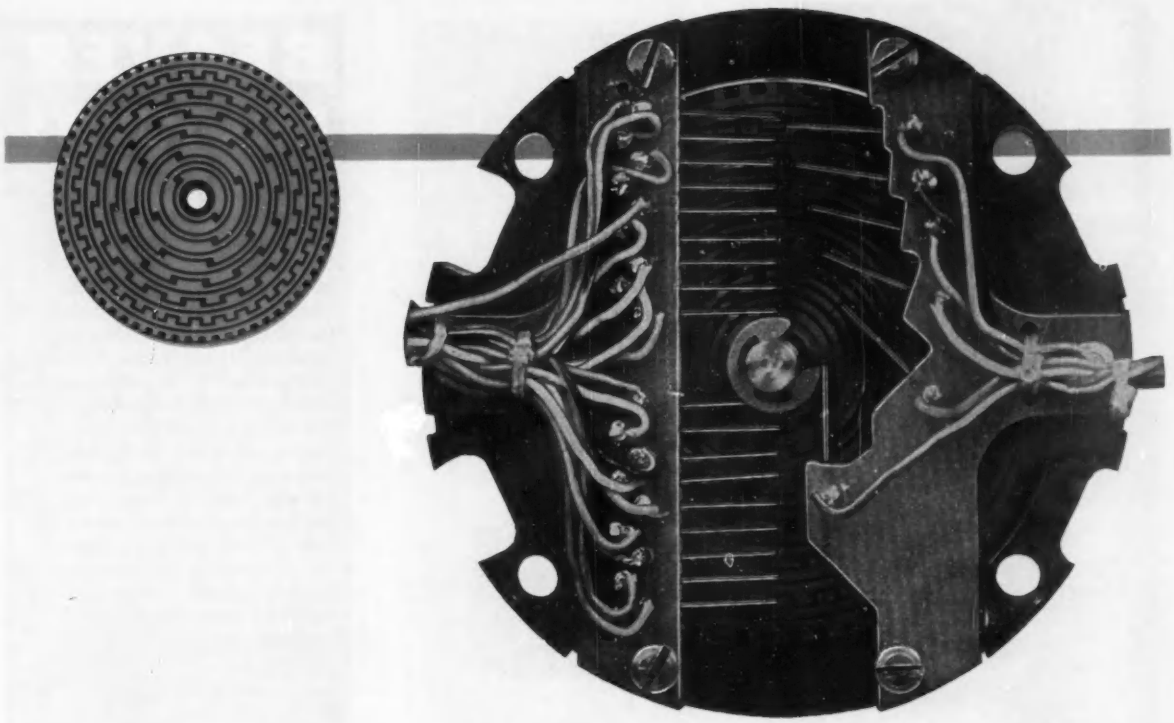
This new mercury filled measurement system consists of a Bourdon tube element that plugs into any of four positions of the manufacturer's receiver/recorder, and a self-compensating capillary tube. Plain or coiled bulbs attached to the capillary tube sense temperatures from −39 to +1,200 deg F. These temperatures may be transmitted along the capillary tube for as long as 200 ft with ambient error of ½ percent per 200 deg F per 100 ft.—Bailey Meter Co., Cleveland, Ohio.

Circle No. 330 on reply card



SPRING DRIVEN GYRO

The rate gyro shown above is spring driven, designed for applications where immediate, short term data monitoring is required. Operating speed is reached in 100 millisec after firing by



Norden converters eliminate external electronics, simplify circuitry by non-ambiguous, self-selecting brush design

Unique Norden self-selecting V-scan pattern translates analog input into digital electrical representation by means of self-contained, non-ambiguous, dual brush-selection logic. This Norden design

- offers the *only* shaft position encoders to qualify under MIL-E-5422D and MIL-E-5272A.
- simplifies total system design and reduces cost.
- has provision for automatic error-monitoring.
- has precision brushes, fewer components and unambiguous output assuring highest reliability.
- saves space . . . ideal for subminiature techniques.
- permits direct parallel readout accurately following the shaft position even at highest shaft speeds.
- has longer life because no load current-carrying brush ever commutates; insulation of only 19% of disc area minimizes brush wear and insulation dust.

MODEL NO.	TOTAL COUNT	REVOLUTIONS PER COUNT	(1 PART IN) ACCURACY
ADC-ST7-BNRY	2^7	1	128
ADC-13-BNRY	2^{13}	64	8192
ADC-19-BNRY	2^{19}	4,096	524,288
ADC-ST8P-BNRY	2^8 (with parity)	1	256
ADC-ST9-BNRY	2^9	1	512
ADC-ST10-BNRY	2^{10}	1	1024

These Norden self-selecting V-Brush encoders fit a wide variety of applications. For complete specifications and drawings, call Norwalk, Connecticut, TEmple 8-4471. If your requirements demand special variations, Norden engineers will work out a custom design.

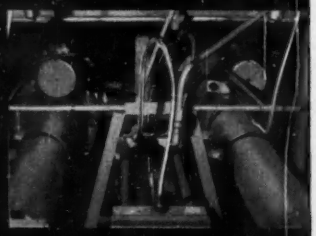
NORDEN

UNITED AIRCRAFT CORPORATION
NORDEN DIVISION
NORWALK. CONNECTICUT

CIRCLE 137 ON READER SERVICE CARD 137

Where actuating control and precision are paramount

—like in a giant supersonic wind tunnel



—or a precision machine tool

you'll find "BEAVERS"

BEAVER ball screws are specified by engineers around the world for control of motion. Compressing solid steel wind tunnel walls, 1600 feet square against inconceivable pressures and holding error to .008" in an 8 foot stroke—or extreme accurate 3 dimension positioning of numerically controlled machine tool are all "naturals" for this equipment.

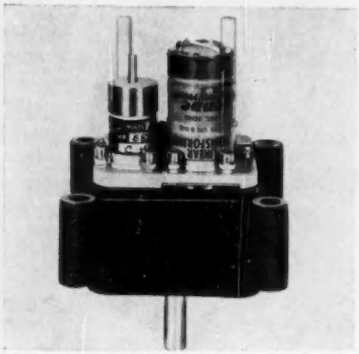
Can your product be made more efficient with Beaver Ball Screws? Write for literature.

Beaver Precision Products INC.
CLAWSON, MICH.

NEW PRODUCTS

solenoid actuated release. Chief advantage over electric motor powered units is low cost and low power requirement (0.2 watt-sec). Price in production quantities: about $450.—Humphrey, Inc., San Diego, Calif.

Circle No. 331 on reply card



FOR AIR CONTROL

Designed for a specific purpose—to transmit the position of control surface actuators to an automatic flight control system—this transducer converts mechanical shaft input to precise linear electrical output when 28 vac is applied. Backlash has been held to 6 min max. Weighing only 9 oz, the compact unit measures $1\frac{7}{8}$ in. square by 3 in. high. The device will operate in ambient temperatures of 85 deg C continuously or of up to 100 deg C intermittently. Shaft inputs up to 50 deg can be accepted, and the linear transformer returns to EZ within ± 3 min of arc.—Clifton Precision Products Co., Inc., Drexel Hill, Pa.

Circle No. 332 on reply card

CONTROLLERS, SWITCHES & RELAYS

TWO-BIT SWITCH

Though for size comparison, a quarter will cover it, the manufacturer of this switch claims it has all the reliability and performance characteristics of a quality relay. The hermetically sealed switch is essentially a relay with the coils removed. The difference is that this switch is operated mechanically by pushbutton instead of electromag-

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

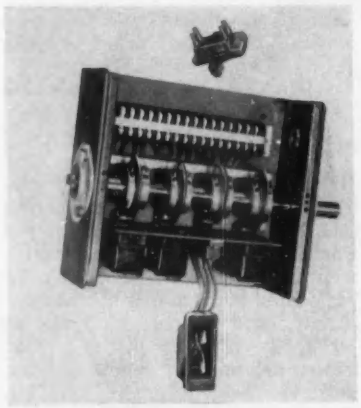
netic force. Minimum number of operating cycles: 50,000. Rated load: 28 vdc and 115 vac.—Leach Corp., Relay Div., Los Angeles, Calif.

Circle No. 333 on reply card

BOUNCE-FREE SWITCHES

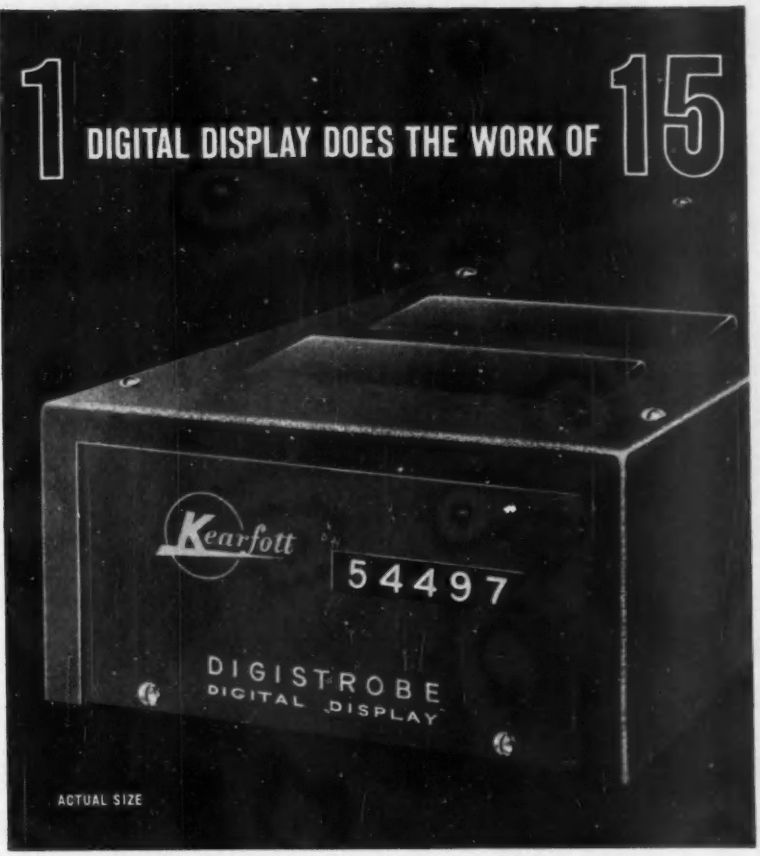
Designed to eliminate spurious voltage pulses caused by contact bounce, four new switches include a compact circuit package along with the mechanical switch to produce a bounce-free device. The switches were developed for use in high speed equipment that operates in less than a microsecond. Outputs of the four devices are positive or negative for resistive loads of 100-500 ohms or over 500 ohms, respectively. The circuit package can be furnished with a variety of the manufacturer's pushbutton or toggle switches or separately for use with spdt switches. Price: in the $20 range. —Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle No. 334 on reply card



CAM LIMIT SWITCH

These plug-in rotating cam limit switches can be applied to any operation where there is shaft rotation.



NEW KEARFOTT DIGISTROBE* DISPLAY

Kearfott's new, highly compact Digistrobe digital display utilizes the stroboscopic principle to produce an exceptionally high-definition readout in the actual size shown here. Through the use of a unique shutter arrangement, a single diode-encoding matrix is shared by all columns (5 in the standard model), resulting in substantial savings in electronic components and circuitry. The fast response time of the Digistrobe (56 milliseconds transition from one five-digit quantity to a totally different one) permits a single unit to sample several different inputs on command through an input selector switch. Up to 15 individual displays of existing types can thus be replaced by a single Kearfott Digistrobe!

Incorporating only two moving parts and exclusively solid-state switching circuitry, the Digistrobe has extremely long life expectancy and requires minimum maintenance and service. Operation is directly from the output register of a computer, counter or allied equipment, eliminating the cost of intervening circuitry. Two years of extensive laboratory tests assure compliance with Kearfott's rigid standards of quality. For complete data and specifications, write for Digistrobe bulletin.

*Kearfott Trademark

GD

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

SENSITIVE SENTINEL

is a good description of the Barton 257 differential pressure indicating switch. Accurate, responsive, easy to read and infinitely dependable, the 257 is ideal for energizing alarm circuits when limits of flow, level, or differential pressure are exceeded. Like many Barton instruments, the 257 D.P. switch has as its heart the rupture-proof dual bellows Barton meter body—proved beyond doubt to be the finest in the field. For new standards of accuracy and dependability in your measurement and control instruments, look to the leader—buy **BARTON**®

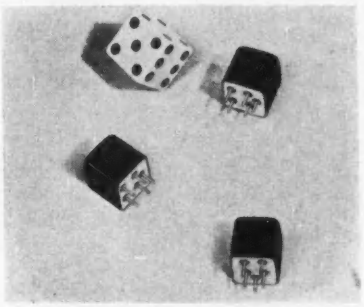
BARTON INSTRUMENT CORPORATION • MONTEREY PARK, CALIFORNIA

140 CIRCLE 140 ON READER SERVICE CARD

NEW PRODUCTS

Circuits can be disconnected or removed for maintenance because the switches' plug-in snap receptacles are permanently wired to the screw terminals. By adjusting a single screw and rotating the cams, a continuous range of open and closed circuits is obtained between 8 and 360 deg. The spot switch contacts are available in NEMA Type 1, 4, 7, 9, and 12 enclosures with from 2 to 24 circuits. Current rating is up to 15 amp at 115 vac. Optional features include reset mechanism for one revolution clutch operation, special mounting brackets, and a built-in gear reducer. Price for NEMA Type 1, four-circuit switch: $165.–Gemco Electric Co., Detroit, Mich.

Circle No. 335 on reply card



DICE-SIZED RELAY

As shown above, these Dice-Cube spdt relays are ½-in. cubes, allowing a component density of 13,824 per cu ft. Long or short leads for printed circuits or hook terminals for standard wiring are available. Terminals are arranged to fit standard 0.100 grid spacing with one pin offset for keying. Rating is from dry circuit to 1 amp resistive.–Hi-G, Inc., Windsor Locks, Conn.

Circle No. 336 on reply card

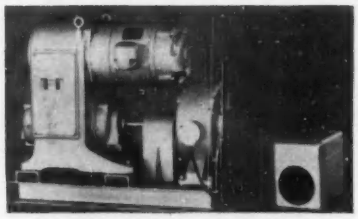
PLUS . . .

(337) An **indicating temperature control** made by **United Electric Controls Co.**, Watertown, Mass., features two separate switches that permit switch action above or below the index point and control of up to four independent circuits in a temperature range of −150 to +650 deg F. . . . (338) **Differential pressure switch** designed by **F. W. Dwyer Mfg. Co.**, Michigan City, Ind., for low pressure ranges is tamper proof, weather proof, and explosion proof. . . . (339) **Photoswitch Div., Electronics Corp. of America,** Cambridge, Mass., has made available

a transistorized photoelectric control package that operates on light impulses as short as 0.015 sec at 20 ft.

Circle Nos. 337, 338, or 339 on reply card

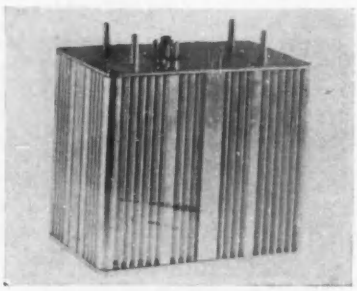
POWER SUPPLIES



SOURCE UNIT

This unit of the NoBrush line of variable frequency sources has a standard frequency range of 380 to 420 cycles with a voltage variable between 105 and 125 volts. Input is three-phase, 60-cycle; output is three-phase, four-wire, 5 kva. No regulator or exciter is necessary. Manually adjustable variable ratio pulley drive and autotransformer allow any combination of voltage and frequency within the machine's range. Units with higher voltage ranges and frequency up to 1,000 cycles are also available. Georator Corp., Manassas, Va.

Circle No. 340 on reply card



TOLERATES SHORTS

The SC100-1 is a transistorized power supply featuring sealed construction, remote programming, and variable current limiting. Designing as a power source for automatic test equipment and instrumentation systems, it has a regulation to within 0.5 percent for load changes, 0.2 percent for line variations, and external control of output current within its range regardless of load. Ripple is 250 microvolts rms. Continuous short circuits can be tolerated. The previous current values return when the short is removed. The 100-volt, 100-ma output is continu-

HIGHLY RELIABLE

SHAFT POSITION-TO-DIGITAL CONVERTERS

Kearfott's rugged shaft position-to-digital converters are resistant to high shock and vibration and high and low temperature environments. Ideally suited for missile applications, these converters are available for many uses, including latitude, longitude, azimuth or conventional angular shaft displacement conversion and decimal count conversion. Exclusive drum design provides large conversion capacity (typical unit 2^{15}) in smallest available size. Combination counter-converter assemblies for both visual and electrical readout also available.

CHARACTERISTICS:

Kearfott Unit No.	P1241-11A (425856-1)	P1240-11A (423879-1)	Y1240-11A (428646-1)	Y1241-11A (428645-1)	U1240-11
Code (1)	C.B. (Gray)	B.D.	B.D.	B.D.	B.D.
No. of Drums	5	3	3	2	4
Range	0-32,768(2^{15})	(+)0to(+)999 (−)999 to (−)0	0 to 359.9	0 to 359	0 to 359.9
Bits per Revolution	16	20	40	40	40
Revolutions for Total Range	2,048	100	90	9	90
Total Number of Bits	32,768	2000	3600	360	3600
Volts D.C.	10.5	23	23	23	23
Current (ma.)	20	20	20	20	20
Inertia (gm. cm.2) (2)	20	28	158	104	100
Unit Diameter (in.)	1 3/16	1 3/16	1 15/16	1 15/16	1.875
Unit Length (in.)	3	1 15/16	2 3/16	1 49/64	2.8125
Life (3)	10^6 revolutions or 10^3 hours				
Static Torque (in.-oz.) (4)	2 (break) 1 (running)	.5	1.0	1.0	1.0
Weight (oz.)	5	4	7.75	5.75	6.5
Maximum Speed (RPM)	600	400	300	300	700
Operating Temperature Range (°F)	−65 to +200	−65 to +350	−65 to +350	−65 to +350	−65 to +350
Shock (g's)		15	15	15	15
Vibration	In accordance with MIL-E 5272A, Procedure 1				

(1) B.D. (Binary Decimal), C.B. (Cyclic Binary).
(2) Inertia measured at maximum trip.
(3) Under recommended conditions.
(4) At room temperature.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Now you can mount

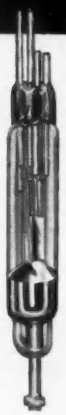
CLARE

BILLION-
OPERATION

RELAYS

on your own printed circuit board

Typical Clare mercury-wetted relay steel-enclosed modules for circuit-board mounting. From top: HGSM Relay Module, HGM Relay Module, HGPM Relay Module. Epoxy molded Relay Modules are also available.



Mercury-wetted contact relays, steel-enclosed and ready for mounting on your own assembly line, give you Clare reliability in operation, combined with new ease of application and handling. Clare HG and HGS relays have test records of over 10 billion operations, without maintenance or change in characteristics. In these new modular cases, they're sturdy, magnetically shielded, easily replaceable.

Choose either the standard Clare HG relay, or the HGS—super-fast and super-sensitive. You'll gain extra convenience and increased component-density with these Clare Relay modules.

Each relay contains one or more of these magnetic switches. Mercury-wetted contact surfaces are continually wetted by capillary action; they never bounce, never get dirty, never weld, and never wear out.

Get Bulletin CPC-8 for detailed specifications, characteristics, dimensions: Ask your Clare representative, or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ontario. Cable address: CLARELAY.

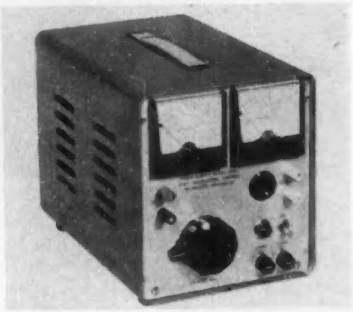
C. P. CLARE & CO.

Relays and Related Control Components

NEW PRODUCTS

ously variable and can be grounded on the positive or negative side. Price: $220 in quantities of 100.—Mid-Eastern Electronics, Inc., Springfield, N. J.

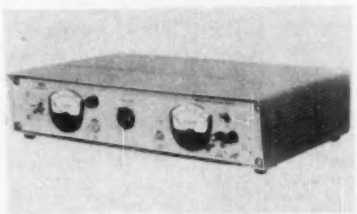
Circle No. 341 on reply card



HIGH CURRENT

Power supply Model 4025 delivers 4 amp ac or 3 amp dc with less than 1 percent ripple. Output voltage is 0-150 vac or 0-200 vdc. An isolation transformer protects the unit from line voltage. Output impedance is 15 ohms; recovery time is 30 millisec for half-current step changes. Device measures 8 x 9 x 12 in. and weighs 35 lb. Price: $149.95 complete or $125.38 less meters.—Eder Engineering Co., Inc., Milwaukee, Wis.

Circle No. 342 on reply card



RAPID RESPONSE

These transient-free power supplies have a response time of 10 microsec. All models use a dual-differential amplifier which minimizes drift. Current gain is 1 million, voltage gain is 10,000 but phase rotation is only 180 deg. Regulation against load and line variations can be held to 100 parts per million. These solid state devices have output range of 0 to 150 volts, max current of 30 amp. Minimum warranty is for 5,000 hr. Price of representative model (32 volts at 10 amp): $695. Power Devices, Inc., Los Angeles, Calif.

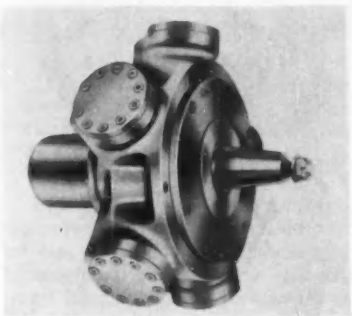
Circle No. 343 on reply card

CONVECTION COOLED

A swing-open back permits easy servicing of this compact (3½ in. high, rack width) transistorized power supply. Convection cooling eliminates blowers, giving the unit a rating of 24-hr operation at 50 deg C ambient. Thermal overload protectors, circuit breakers, and fuses guard the equipment. The complete unit is guaranteed for 5 years. The 5-amp model costs $395; the 10-amp device, $510. Meters are $30 more.—Lambda Electronics Corp., College Point, N. Y.

Circle No. 344 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS



BRITISH MOTORS

These hydraulic motors, made in England and now available in the U. S., can be coupled directly to conveyors, winches, rolling mills, or similar equipment that requires high torque at low speeds. There are two models. A seven-cylinder unit operates at a continuous torque of 6,600 ft-lbs with peaks to 10,000. Speed is from 0 to 75 rpm. The five-cylinder model ranges from 0 to 100 rpm with a 4,600 ft-lb continuous torque and peaks of 7,000. In both models a control valve regulates the direction of rotation.—Double A Products Co., Sub. of Brown & Sharp Mfg. Co., Manchester, Mich.

Circle No. 345 on reply card

PNEUMATIC VALVE

Up to 178 percent greater conductance is claimed over other gate valves by the manufacturer of this new series. Available in nominal 2, 4, and 6-in. openings, they are cast as a single unit to avoid gasket leakage or outgassing

SHOWN 1½ NORMAL SIZE

0.1% LINEAR OUTPUT OVER TEMPERATURE RANGE

SIZE 11 DC TACHOMETERS

These Kearfott DC tachometers are unusually durable and specifically designed to provide reliable service over a long life. R9608-001 is an uncompensated unit ideally suited to function as a stabilizing element in a standard DC servomechanism. The R9608-002 model offers the precision required in computing applications and is temperature compensated to maintain its high accuracy over the temperature range of −15°C to +71°C, with variations of no more than .1% of values specified at 25°C.

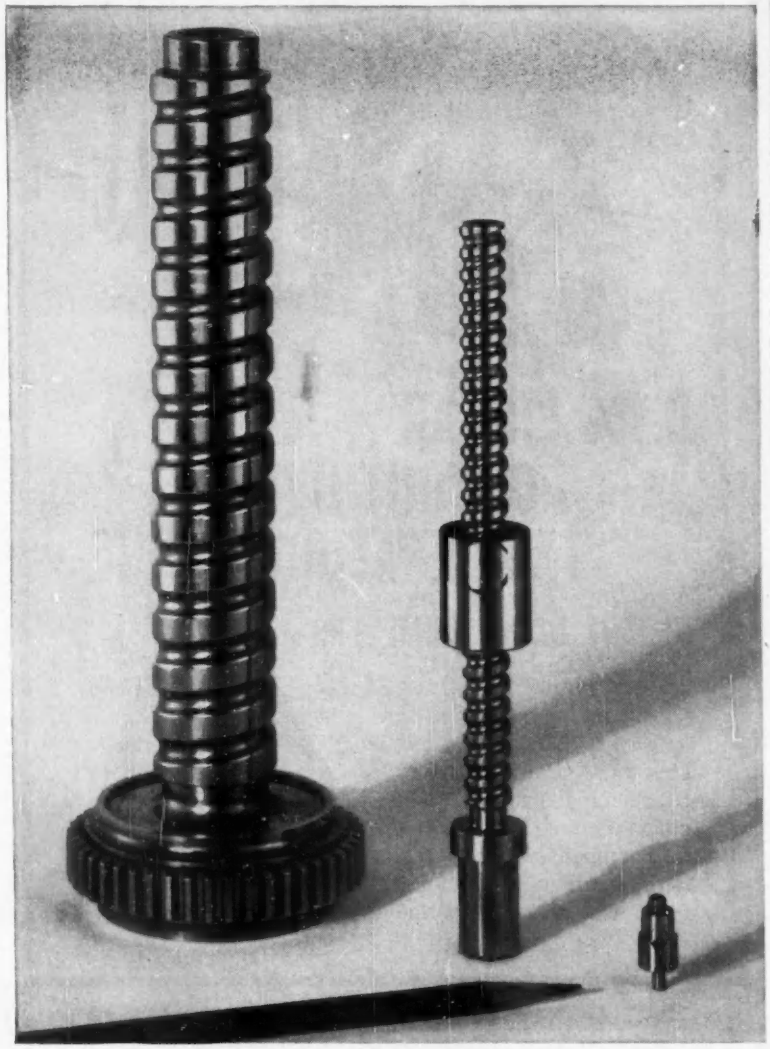
		R9608-001	R9608-002
TYPICAL ELECTRICAL DATA	Output (volts/1000 rpm)	7 (typical) .5-30 available	2
	Rated Speed (rpm)	3600	5000
	Linearity (% to 3600 rpm)	.07	.1
	Winding Resistance (ohms)	125	
	Output Impedance (ohms)	—	36
	Ripple Voltage	2% above 100 rpm	2.5% at 3600 rpm
TYPICAL MECHANICAL DATA	Friction Torque (in. oz.)	0.25	0.25
	Rotor Moment of Inertia (gm-cm²)	7	8
	Weight (oz.)	5.5	5

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

PERFORMANCE · RELIABILITY · COMPACTNESS · PRECISION



Kidde Ballscrews now in production include these ranges:

SIZES—3/16 to 1¼ inches (dia.), 19/32 to 8 inches (thread length).

WORKING LOAD—30 to 2000 lbs.

TEMPERATURE—minus 65°F to plus 840°F.

PRECISION—lead error of 0.0003 inch/ft.

Kidde ballscrews have a minimum amount of backlash and friction, perform functions demanding rapid reversibility of heavy loads. These abilities make them suitable for an extremely wide variety of applications in aircraft, missiles, and ground support equipment, including their use in aerodynamic surface controls, steering mechanisms, nuclear scram rod controls, and radar scanning drives. For more information ask for Brochure A-28.

K Kidde

Kidde Aero-Space Division

Walter Kidde & Company, Inc., 117 Main St., Belleville 9, New Jersey

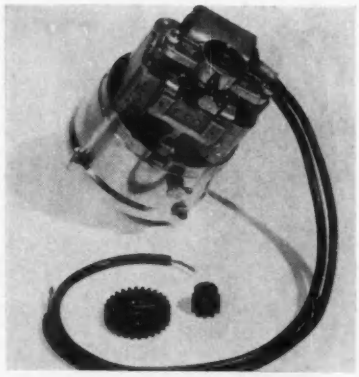
District Sales Engineering Offices: Boston, Mass. • Dallas, Texas • Dayton, Ohio • Huntington, L. I., N. Y. St. Louis, Mo. • San Diego, Calif. • Seattle, Wash. • Van Nuys, Calif. • Washington, D. C. Walter Kidde-Pacific, Van Nuys, California • Walter Kidde & Company of Canada Ltd., Montreal, Toronto, Vancouver

The words 'Kidde', 'Lux', 'Inflatair' and the Kidde seal are trademarks of the Walter Kidde & Company, Inc.

NEW PRODUCTS

near the flow path. The valves may be used with operating pressures down to 10^{-6} mm Hg. Bodies are vacuum cast aluminum for minimum porosity. A gasket end plate permits easy valve removal for cleaning or converting to another type of operator.—Consolidated Vacuum Corp., Rochester, N. Y.

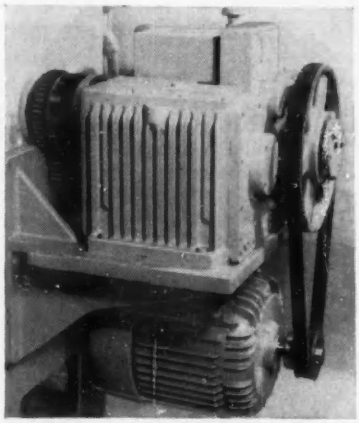
Circle No. 346 on reply card



SUBFRACTIONAL HP MOTOR

Extra heavy broached nonslip gears, positive-locked high tensile bearings, and a double-action brake are said to make this electric motor maintenance free for many years. A thermal overload divide cuts out the motor in the event of operating unit, malfunctions. Speedway Motor Div., Thor Power Tool Co., LaGrange Park, Ill.

Circle No. 347 on reply card



HIGH POWER MPA

This new mechanical power amplifier model can amplify the output of a 1/30-hp low powered servomotor

to 4 hp. Continuous power is provided over a 50 to 1 speed range with greater ranges available. External cooling circulates oil throughout the housing to give continuous hp ratings. Minimum maintenance is needed. There are no critical assemblies or adjustments. Servomotor output is said to be amplified in such a way that the MPA functions as a high powered servomotors. Price $2,300.—Electronics Div., Seneca Falls Machine Co., Seneca Falls, N. Y.

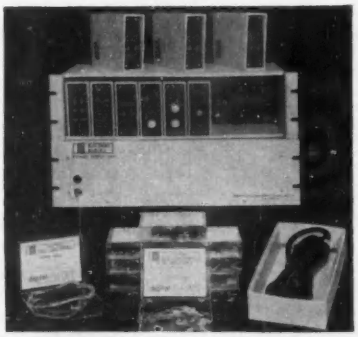
Circle No. 348 on reply card

PLUS. . .

(349) A self-contained, miniaturized **servo-synchro repeater** that features a transistorized power supply and amplifier has been placed on the market by **Orbit Instrument Corp.**, Syosett, N. Y., at prices varying from $750 to $1,250. . . . (350) The **Avionic Div. of John Oster Manufacturing Co.**, Racine, Wis., has introduced a $\frac{7}{8}$ in. diam **timer motor** designed to withstand 8,000 g axial shock and 500 g transverse shock. . . . (351) A life expectancy 20-100 times greater than that of conventional motors is claimed for a **brushless transistorized motor** developed by **Eastern Air Devices, Inc., Sub. of Crescent Petroleum Corp.**, Tulsa, Okla.

Circle Nos. 349, 350, or 351 on reply card

COMPONENT PARTS



BUILDING BLOCK KIT

Various logic operations can be tested and demonstrated with this basic selection of building block logic circuit packages and accessory equipment. The kit can serve as a classroom aid or as laboratory apparatus. Included are up counters, down counters, four-bit shift registers, subtractors, and many others. All logical interconnec-

hays

RAMBLINGS ON INSTRUMENTATION

My Pilgrimage to Poopley

POOPLEY-ON-SLOUGH, NUTTINGSHIRE, U.K.

The sight from my window as I write, dear colleagues, is one to warm the cockles of any instrument-oriented heart. As you have already guessed from the dateline, yours truly is at one of the great shrines of Science, famous Poopley, where the first British Thermal Unit made its appearance some 178 years ago.

The tiny village is little changed except today, on the exact site where the Event took place, stands a modest monument built from contributions of BTU buffs the world over.

When the tram pulled into Poopley yesterday my first act was to ask a rustic villager where the Monument was. A proud light kindled in his eyes.

"Aye, mon, it'd beein' oe'r there'n mought 'nuff 'erg," he told me, tugging his forelock. (Learned later the chap was game-keeper at the old Chatterley place.) I hurried off to find someone who spoke English. Eventually I found the Monument.

There, flanked by fluted columns, was the Flame, the undying flame that heats the Calibrator, producing the standard British Thermal Units that are distributed by the thousands throughout the Free World. Before it, a smallish man with a walrus mustache was peering fixedly. Col. Gideon W. Belcher himself, Keeper of the Flame and walking encyclopedia of BTU lore!

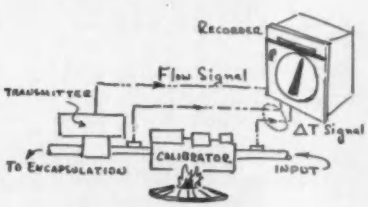
Reverently, the Colonel displayed the key to the entire operation, a Hays BTU Meter chronicling with rhythmic monotony the beautiful precision of the thermal units being generated in the Calibrator. The Colonel removed his Homburg and I followed suit. Bareheaded, we stood in the flickering light, watching the lovely, fluid movements of the recorder pen, its graceful Palmer-method scallops mirroring BTUs at the point of sheerest perfection. It was a moment for posterity.

The Colonel blew his nose. "Wizard device, that," he rumbled. "Linear record of flow, Delta T and BTU all on the same chart!"

"Plus integration of BTU", I breathed.

"Quite. Remote flow transmitter. Resistance bulbs. Good show! Can't afford less on this job, you know. If the BTU ever went to pot I shudder to think!"

Later I listened raptly as the Colonel told of his harrowing experiences as Keeper of the Flame; such as the night a gaggle of Scottish Nationalists made an abortive attempt to blow it out . . . that touchy time when a Russian scientist declared the superiority of Iron Curtain-type thermals. (The Colonel caned the bounder thoroughly and the lights burned late on Downing Street *that* night, I tell you.)



Sketched from life at Poopley, shrine of the British Thermal Unit.

Well, twilight is descending on dear Poopley, chaps, and I haven't even touched on the preparations going forward for the 178th Anniversary Celebration. May I only say you will be proud when you see the newsreels.

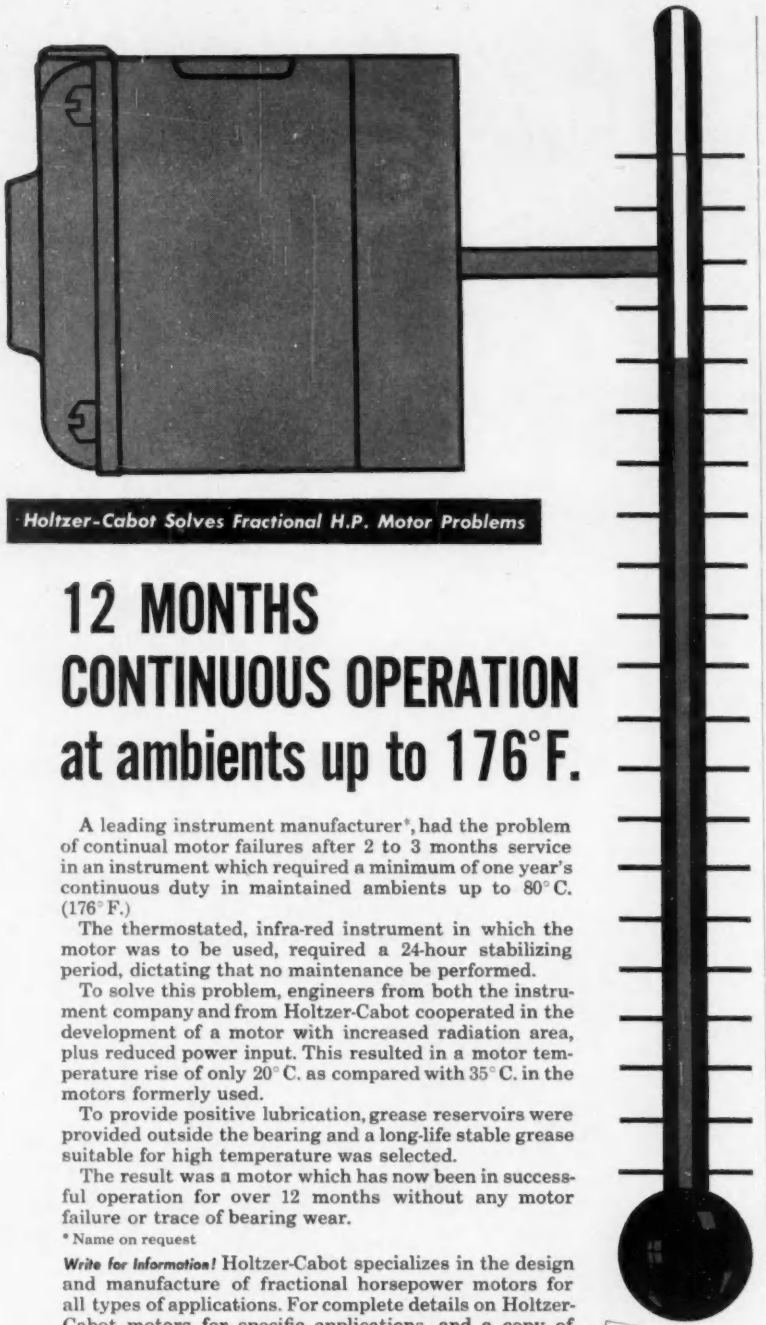
Finances, unfortunately, are a thorny problem. I am sure none of you would want the Celebration to be less than a rouser. Need I remind you that, with each purchase of a Hays single-case BTU Meter, we make a substantial contribution in the purchaser's name to the Committee for Everlasting Maintenance of the British Thermal Unit.

So, dear colleagues, start the New Year selflessly. Buy a Hays BTU Meter, for yourself and a friend. Your generosity will be gratefully acknowledged by Col. Belcher himself.

Phil A. Sprague

President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA



Holtzer-Cabot Solves Fractional H.P. Motor Problems

12 MONTHS CONTINUOUS OPERATION at ambients up to 176°F.

A leading instrument manufacturer*, had the problem of continual motor failures after 2 to 3 months service in an instrument which required a minimum of one year's continuous duty in maintained ambients up to 80° C. (176° F.)

The thermostated, infra-red instrument in which the motor was to be used, required a 24-hour stabilizing period, dictating that no maintenance be performed.

To solve this problem, engineers from both the instrument company and from Holtzer-Cabot cooperated in the development of a motor with increased radiation area, plus reduced power input. This resulted in a motor temperature rise of only 20° C. as compared with 35° C. in the motors formerly used.

To provide positive lubrication, grease reservoirs were provided outside the bearing and a long-life stable grease suitable for high temperature was selected.

The result was a motor which has now been in successful operation for over 12 months without any motor failure or trace of bearing wear.

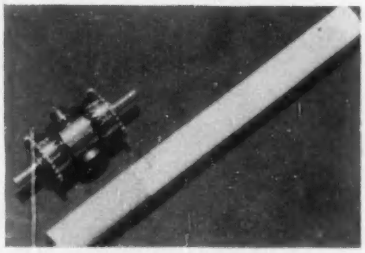
* Name on request

Write for Information! Holtzer-Cabot specializes in the design and manufacture of fractional horsepower motors for all types of applications. For complete details on Holtzer-Cabot motors for specific applications, and a copy of "Key Factors in Selecting AC Motors for Instrument Service" write direct or use Readers Service Card.

HOLTZER-CABOT
MOTOR DIVISION
National Pneumatic Co., Inc., Boston 19, Mass.

tions are made on the graphic front panels by stacking banana-jack patch cords. The unit can be expanded with other fully compatible equipment. Price: $1,038.–Digital Equipment Corp., Maynard, Mass.

Circle No. 352 on reply card



TINY DIFFERENTIAL

Added to a line of single spider gear differentials is this $\frac{3}{32}$-in. model which gives extremely good accuracy in additive and subtractive operations while functioning with minimum friction and backlash. Working circle for the device is 0.585 in. in diam, and the unit weighs just $\frac{1}{2}$ oz with typical end gears. Minimum breakaway torque is 0.07 oz-in.; maximum lost motion is 20 min of arc. Unit is priced at about $60.–Components Div., Ford Instrument Div. of Sperry Rand Corp., Long Island City, N. Y.

Circle No. 353 on reply card

VERSATILE HEADS

Up to 20 channels per in. can be recorded simultaneously or tape or drum using this new series of basic in-line magnetic heads. Either analog or digital applications can be accommodated with six compatible track for-

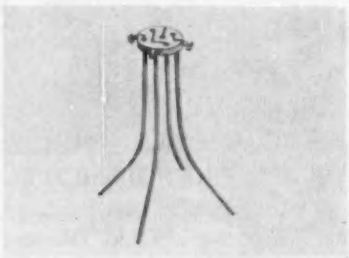
mats: track widths, 0.020-0.050 in.; track spacing, 0.050-0.140 in.; 7, 8, 13, 14, and 20 channels per in.; tolerance to ± 0.002 in. Colinearity of leading and trailing edges of gaps is held to within ± 50 microin. in the head stack. Price: $50-75 per channel. —Brush Instruments, Div. of Clevite Corp., Cleveland, Ohio.

Circle No. 354 on reply card

UNIVERSAL SWITCHER

Truly universal is the manufacturer's description of these high speed switching elements for use in digital logic networks. Their unique design allows these modules to form all major building blocks required for digital systems. Each half of the individual elements functions as a four-input decision element of NOR or NAND logic. Modules can be connected together to provide eight-input units, flip-flops, delays, counters, and shift registers. Reliable operation at 5-Mcps input repetition rates is possible.—Tele-Dynamics Div., American Bosch Arma Corp., Phila., Pa.

Circle No. 355 on reply card



CIRCUIT SUBSTRATES

Small Mykroy (glass-bonded mica) slabs with leads molded in position and surfaces lapped to a 10-microin. finish make up these newly announced circuit substrates. Smooth surface, rigidity, and high resistivity (5×10^{11} ohms per cm) make this material particularly suitable for substrates. The manufacturers also have a process which deposits 0.0005-in. thick copper conductive circuits in the holes and surfaces of the slab. Price for representative model in quantities of 500: $2.—Electronic Mechanics, Inc., Clifton, N. J.

Circle No. 356 on reply card

PLUS . . .

(357) Newly developed at **Magnetic Controls Co.**, Minneapolis, Minn., is a line of miniature solid state **proportional amplifiers** for controlling up to 100 watts dc in temperature controls. . . . (358) **Hagan Chemicals & Con-**

ELIMINATE
MATHEMATICAL COMPUTATIONS...

W&T PRECISION
MERCURIAL MANOMETERS

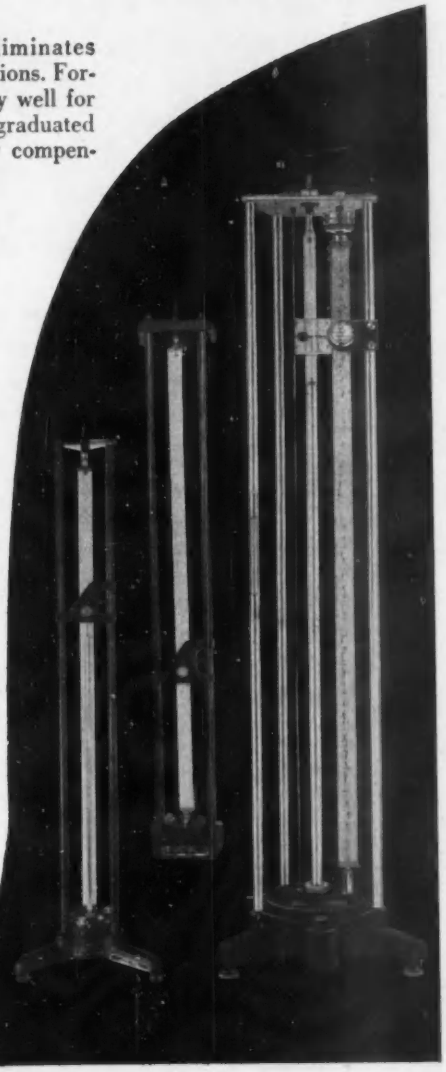
Simple knob adjustment eliminates temperature and gravity corrections. Forget about indexing the mercury well for each reading. W&T's specially graduated manometer scale automatically compensates for well level depression.

The Wallace & Tiernan FA-187 mercurial manometer also gives you:

- ★ Accuracy 1/5000
- ★ Range 0 to 31.5″ Hg or equivalent
- ★ Readings to 0.005″ Hg
- ★ Magnifying eye piece for exact reading
- ★ Magnetic vernier eliminates meniscus reading
- ★ Specially calibrated scale

Use the W&T mercurial manometers as calibrating standards for absolute pressure or easily modify them to perform as barometers, differential or vacuum indicators.

For further information, write Dept A-128.28



WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

ENGINEERING
REPORT
ON BENDIX COMPONENTS

PRECISION SIZE 5 MOTORS NOW AVAILABLE FROM STOCK

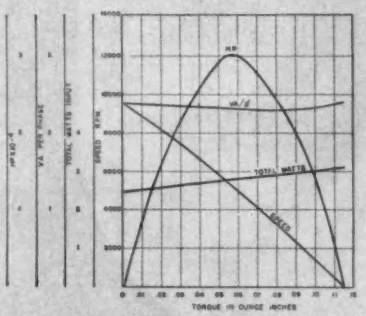
Available for immediate delivery, these miniaturized Bendix® motors (type number CK 1066-40-A1) are designed for applications where space and weight requirements are at a minimum. So small that four can be packaged in a square inch, these motors are ideally suited for missile instrumentation and similar miniaturized applications. The motor has a tapered shaft; however, units may be obtained with other type shafts and with center tapped control windings.

TYPICAL MOTOR CHARACTERISTICS

Voltage	
Fixed phase	26 volts
Control phase	26 volts
Frequency	400 cycles
Stall Current*	
Fixed Phase	100 ma
Control Phase	100 ma
Stall Impedance*	
Fixed Phase	260 = 184.5 + J183.5 ohms
Control Phase	260 = 184.5 + J183.5 ohms
Stall Power Input* (Total)	3.69 watts
Stall Torque	0.138 oz.-in.
No Load Speed	9900
Torque-to-Inertia Ratio (Stall Acceleration)	44,400 rad/sec²
Operating Temperature Range	−55°C. to +70°C.
Weight	0.88 oz.

*With rated voltage applied to each phase.

AVERAGE PERFORMANCE CURVES



For information on these motors—or similar motors in sizes 8, 10, 11, 15, 20, and 28—write:

Eclipse-Pioneer Division
Teterboro, N. J.

THE Bendix CORPORATION

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

NEW PRODUCTS

trols, Inc., Pittsburgh, Pa., has announced a **converter** at $225 that converts a dc electrical signal into a pneumatic signal with over-all accuracy to within 0.5 percent. . . . (359) New transistorized **voltage comparison amplifier** from **Non-Linear Systems, Inc.**, Del Mar, Calif., combines favorable sensitivity, range, and impedance with $950 price tag.

Circle Nos. 357, 358, or 359 on reply card

ACCESSORIES & MATERIALS

FOR SPECTROPHOTOMETER

The Datagraph is an attachment for the manufacturer's Model DU spectrophotometer which prints wavelength and transmittance information directly on preprinted sheets or strip charts. Several samples of transmittance at one or more wavelengths or a complete spectrum can be plotted. The printer can be attached to the spectrophotometer in a few minutes, and there is no decrease in the basic accuracy of the spectrophotometer.—Connecticut Instrument Corp., Wilton, Conn.

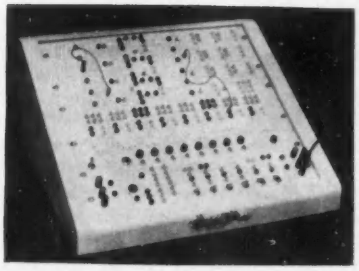
Circle No. 360 on reply card

CLEANS MAGNETIC TAPE

Automatic cleaning of magnetic recording tape is made possible with a new cleaner which operates at high speed (0-300 fpm) and complete safety. Nonflammable, nonexplosive solvents are used. Once tape is in place and the solvent tank filled, the machine automatically completes all operations, including automatic shut-off. Cleaners for ¼, 1, and 2-in. tape

are now available. The price of the last is $6,575.—Computer-Measurements Co., Sylmar, Calif.

Circle No. 361 on reply card



TRAINS IN LOGIC

Versatile and easy to use, the TDC digital logic trainer provides instruction and demonstration aid for training in digital circuit operation, logic design breadboarding, and testing digital circuits. Front panel is made up of 50 prewired digital circuits with symbols for identifying input-output connections and functions. Connections are made with pin jack jumpers. Trainer without power supply is priced at $1,795.—Components Div., Epsco, Inc., Cambridge, Mass.

Circle No. 362 on reply card

RELAY CONVERSION KIT

Standard relays of the manufacturer's PM line can now be modified to meet many switching requirements with a color-selective conversion kit. Replacement are made by putting together a relay from some of the 30 conversion kits available. Each kit has a color code which identifies the use of each component. By keeping a number of conversion kits on hand, the user can reduce relay inventories but still have material for many types of standard and nonstandard relays. — Clark Controller Co., Cleveland, Ohio.

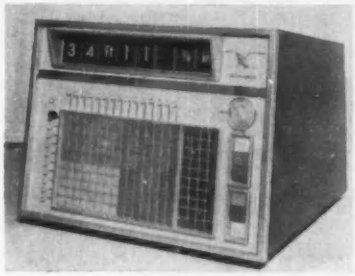
Circle No. 363 on reply card

PLUS . . .

(364) **A word counter** operating at 60, 75, or 100 wpm, which measures message traffic on Teletypewriter circuits and presents the number on its illuminated face, has been announced by the **Western Apparatus Div., of Comptometer Corp.**, Chicago, Ill. . . . (365) Invisible perforations, too small to impede any pen, allow accordian folding for neat filing of these **roll chart papers** manufactured by **Judson-Bigelow Div., Techni-Rite Electronics, Inc., Providence, R. I.** . . . (366) **Dow Corning Corp.**, Midland, Mich., promises improved potting and encapsulating of electronic units with a new superthin fluid silicone rubber (price $4-5 per lb) that cures without heat.

Circle Nos. 364, 365, or 366 on reply card

SYSTEMS



SOLID STATE SYSTEM

This solid state telemetry system performs the three functions of data gathering, constant alarm scanning, and control over a single low grade communication link. Called RATE (Remote Automatic Telemetry Equipment), it serves up to 1,200 points and uses time sharing techniques to avoid multichannel systems. In addition to setpoint control, the system provides for two-condition control operations. Data are gathered at telegraphic speed, identified, error checked, and displayed by digital in-line readout. For use with business machines, perforated tape outputs are available.—Shand & Jurs Co., Sub. of General Precision Equipment Corp., Berkeley, Calif.

Circle No. 367 on reply card

TEMPERATURE CONTROL

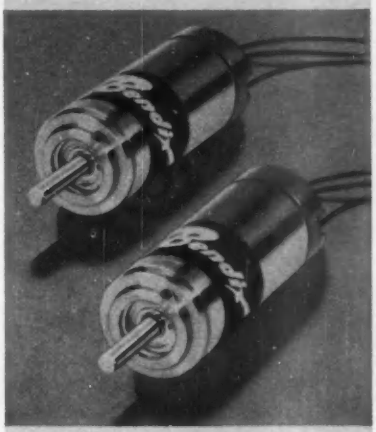
To maintain furnace temperatures up to 1,200 deg within 0.2 deg C, this control system combines a platinum resistance thermometer with an electronic controller. The system operates between 100 watts and 100 kva supplying continuously varying power to the furnace windings. Temperature errors are reduced by using a potentiometer as a controller. This controller automatically compensates for line voltage variations. Price of entire system with a 1-kva reactor: less than $750.—Atkins Technical, Inc., Cleveland, Ohio.

Circle No. 368 on reply card

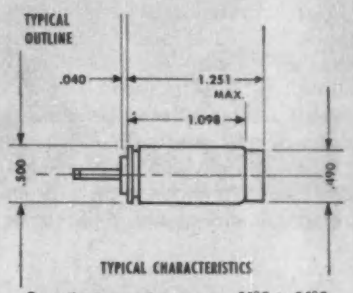
ENGINEERING REPORT ON OTHER BENDIX COMPONENT PACKAGES

AUTOSYN® SYNCHROS

Dependable in miniaturizing control circuitry



These Bendix® size 5 Autosyn synchros are well suited to the needs of missile instrumentation and similar applications requiring miniaturization and weight reduction. Typical characteristics are listed below. For additional information, including comprehensive data on transmitter, control transformer, and differential characteristics, write today.



TYPICAL CHARACTERISTICS

Operating temperature range. −55°C. to 95°C.
Rotor moment of inertia. . . . . 0.25 gm cm²
Weight. . . . . 0.8 oz.
Accuracy. . . . . ±15 minutes

Available as transmitter, control transformer and differential.

Manufacturers of

GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
PACKAGED COMPONENTS

Eclipse-Pioneer Division

THE Bendix CORPORATION

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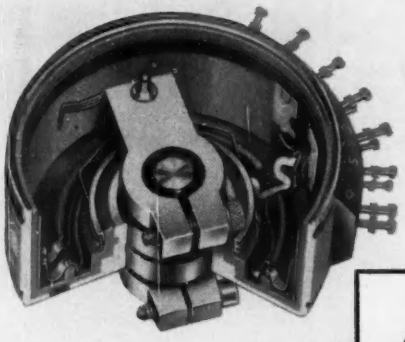
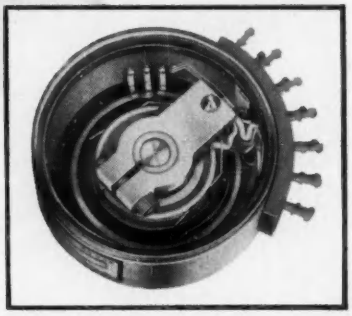


Typical Cross-Section. DeJUR's exclusive process of bonding resistance wire to card permits use of a 3-finger contact brush of lighter material.



Series C-200 Potentiometer with new insulating molding.

Another First for DeJUR

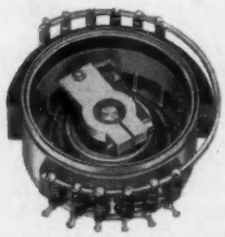
The ONLY POTENTIOMETER with integrally molded insulation, terminal board and terminals.

An exclusive, one-piece molded insulation is featured in these new Series C-200 2″ diameter precision wire-wound potentiometers. Terminal board, tap mounting ring and all internal insulating surfaces are molded integrally into a precision machined aluminum housing.

Unit terminals are permanently cored into position with molded identification numerals. This provides a complete insulating envelope inside the aluminum housing, without joints or interruptions, and eliminates all possible leakage paths. The one-piece molded interior also provides better concentricity than individual fabricated strips, resulting in more uniform wiper pressures, improved linearity and longer service life. Write for detailed literature.

SPECIAL APPLICATION OF C-200 POTENTIOMETER

Attenuator for hearing aid tester consolidates functions of many resistors and switches into a single compact assembly



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ELECTRONIC COMPONENTS

ELECTRONICS DIVISION
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LONG ISLAND CITY 1, N. Y.

WHAT'S NEW

(Continued from page 40)

here. A large turnout of current EDP users and many new prospects did much to heighten this enthusiasm.

The LA visitors witnessed one of the largest displays of EDP hardware ever assembled at a trade show. Most of the important manufacturers in the field participated, and more than a half dozen showed full scale operating systems. Clacking data handling gear greeted prospective buyers at operating displays of Royal McBee's 4000 and 9000 systems; Burroughs' visual records computer; IBM's 1401, Rem Rand's Univac II; Monroe's Monrobot IX, X, and XI; and Clary's DE-60 machine.

• **Little new**—In spite of the diversity of equipment, there were surprisingly few completely new developments unveiled at the show. Exhibitors may be pointing towards the next Business Equipment Exposition to be held in New York in April.

One new line of data processing equipment that did draw much attention was Underwood Corp.'s Data-Flo, shown in the U. S. for the first time. Designed by Olivetti, Italian major owner of Underwood, the accounting machines with paper tape to card and paper tape to magnetic tape converters have enjoyed good success in Europe—over 2,500 sales.

Royal McBee's 9000 was also unveiled for the first time publicly. The computer offers a number of advanced features including automatic in-line records processing. By this means, data can be accepted in random order and all affected records automatically updated in a single uninterrupted sequence. Memory is provided by storage on endless loops of magnetic tape. Each loop can store up to 1 million alphanumeric characters.

• **Telephoned service**—Transmission of data via telephone lines was still new enough to excite many visitors to the Los Angeles show. Large blocks of interested spectators were drawn to IBM's 1001 Teleprocessing system on display. New from IBM in telephone line data processing was its offer to tie in a user's own equipment with one of IBM's 7070 computers for computing time rental.

This setup is in addition to IBM's Service Bureau Corp. subsidiary, which sells an entire data processing service, and its service centers which sell hourly time on computers but only for in-person work at the centers.

—Michael Murphy
McGraw-Hill News

Snow Cools EJCC Attendance, but Fails to Dampen Enthusiasm

NEW YORK—

The worst autumn snowstorm in New York's history—17 inches fell in the city and over 20 inches hit the suburbs—held attendance at the December Eastern Joint Computer Conference to about 2,000, just over half of the 3,500 expected. In fact on the first day of the meeting, not even the speakers were able to struggle into midtown New York after the city's airline, railroad, and bus transportation services had completely collapsed.

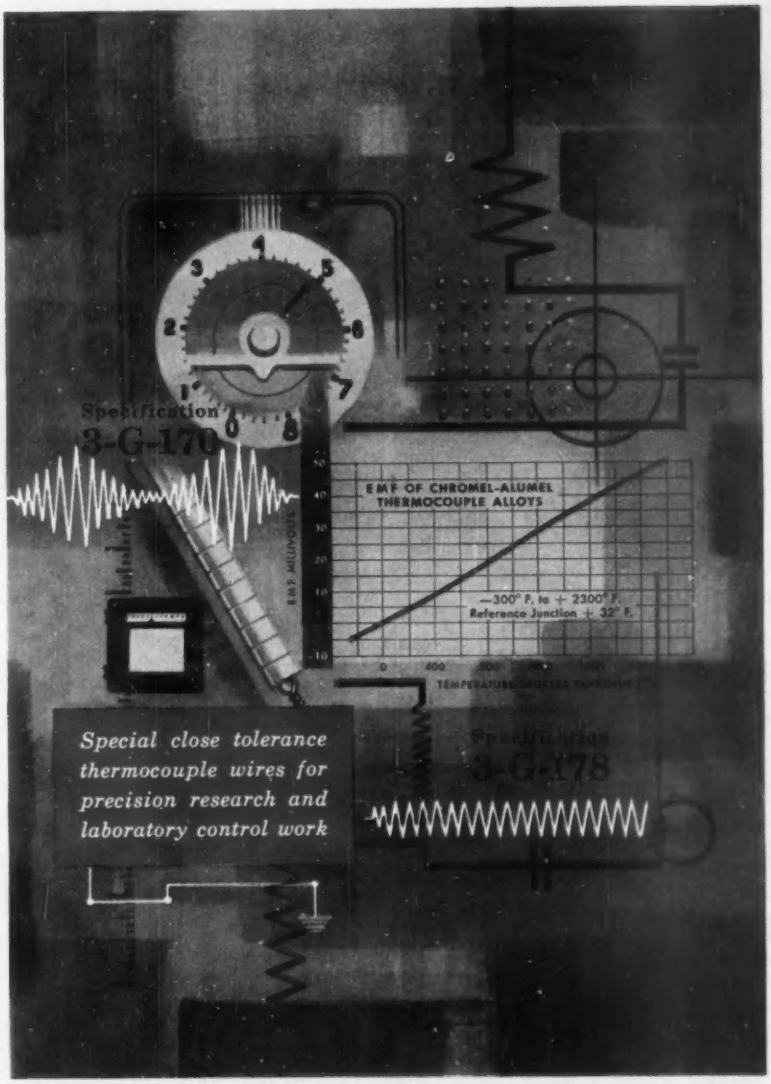
For those persevering enough to battle the mountains of snow, the EJCC show offered continuing evidence that the computer business is still expanding. New machines, more flexible peripheral equipment, and smartly designed digital modules that enable an engineer to design and build his own special purpose information systems add up to a major growing industry in the U.S. Many of these devices and components have been aimed solely at military markets, but now their makers have redesigned them with an eye to industrial applications.

Navigation Computer Corp., for example, a supplier of digital modules for the military, introduced a line of modules for industry. Redesigned to improve noise immunity (supply voltages of plus and minus 50 volts, impart a noise immunity to 10 vdc and 20-volt pulses to the circuits) the devices are transistorized universal flip-flops, packaged four per circuit board. Connector wiring on the back determines whether the module is to operate as a four-bit binary counter, four-bit shift register, binary coded decimal counter, or four individual storage or complementing flip-flops.

At least two computer makers have taken real-time techniques polished for military applications and incorporated them into machines for commercial application. Sylvania's new 9400 data processing system as demonstrated is about equivalent to the IBM 709. But Sylvania can custom tailor a system of even larger size for a user. Rem-Rand's new 490 (see page 23) is a smaller real-time machine. Sylvania's parent company, General Telephone & Electronics Co., is installing a 9400 system for business data processing.

The big Sylvania computer display led a lot of visitors to conclude that this company, which has up to now concentrated all its computer activity in military applications, will shortly officially enter the industrial data processing field.

Other innovations seen or heard


Specification 3-G-170
EMF OF CHROMEL-ALUMEL THERMOCOUPLE ALLOYS
—300° F. to + 2300° F.
Reference Junction + 32° F.
EMF MILLIVOLTS
Special close tolerance thermocouple wires for precision research and laboratory control work
Specification 3-G-178

Chromel-Alumel*

THERMOCOUPLE ALLOYS

Hoskins Chromel-Alumel thermocouple alloys are the world's basic standard of accuracy for controlling the heat treatment of metals—the *only* base metal materials known having established and guaranteed temperature-emf characteristics over a useful operating range from −300° F. for cryogenic applications up to 2300° F. for measuring temperatures in industrial furnaces, nuclear reactors and jet aircraft engines.

Now, in addition to standard guaranteed millivoltage material, these extremely durable, ultra reliable alloys are also being produced in the following special grades for precision quality control:

Specification 3-G-178—Accuracy guaranteed to ½ standard tolerance limits.

Specification 3-G-170—Accuracy guaranteed within ±5° F. over temperature range from 1000° to 2000° F.

Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

**Chromel-Alumel* Trade names you can trust for accurate temperature measurement!*

Genuine Chromel and Alumel are produced exclusively by

HOSKINS MANUFACTURING CO.

4449 Lawton Avenue • Detroit 8, Michigan

Custom-Quality resistance, resistor and thermo-electric alloys since 1908

CIRCLE 151 ON READER SERVICE CARD 151

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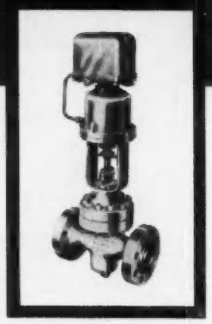
NOW AVAILABLE

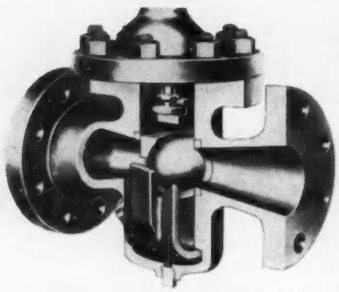
NEW LOW PRICED P-K PAUL CONTROL VALVES



The same unique design that made the P-K Paul Venturi Control Valve the most efficient throttling control valve ever devised **for critical applications** has been incorporated into the new Series G line of P-K Paul Control Valves.

IN ADDITION TO *LOWER COST*

You Get:



- **Higher Flow Capacity**
- **Rangeability Over 100 to 1**
- **Positive Shut-Off**
- **Non-Turbulent Flow**
- **Low Operating Thrust**
- **Self-Purging Action**
- **Resistance to Erosion and Abrasion**

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152 CIRCLE 152 ON READER SERVICE CARD

at the show:

►A new Autonetics machine called Recomp III, designed primarily for solving scientific and engineering problems in a small engineering organization. It can also be used as a real-time computer in process control applications.

►A new Philco data processing system called the Philco 212. The new equipment is primarily a central data processor, four times faster than Philco's 2000 line of machines and capable of being incorporated into a previously installed Philco 2000 series facility.

As a nontechnical development it is likely that the 1960 EJCC will be the last meeting to bear that designation. A move is underfoot to change the National Joint Computer Conference to the American Federation of Information Processing Societies (AFIPS) and to enlarge its scope. Final approval of the change will be forthcoming in about six months.

Marriage Plans Off For English Electric, GEC Ltd.

LONDON—

Two large British electrical equipment manufacturers, General Electric Co. Ltd. and English Electric Co. Ltd., originally reported to be engaged in full scale merger negotiations (CtE, Nov. '60, p. 199), have left each other at the merger door. In a brief and sudden statement issued in London, spokesmen for the two firms announced that the two-month old negotiations had been abandoned.

Strangely enough, the abrupt announcement gave no explanation for the move. Not even a so-called "official" reason was given. This surprised most observers since the companies' stockholder confidence had already been shaken at the announcement of the proposed merger. Market value of EE's shares had slid from about $7.40 to $5, and GEC's dropped from about $6.50 to $5.

Informed London sources are virtually certain the merger fell through over the question of terms. Net book assets of the two firms are just about the same, but EE has roughly a three to two edge in earnings.

Other explanations are current, including reluctance to share each other's commitments, fear of a major move during Britain's unsettled economic situation, and the possibility of GEC's merging with another.

Peaking Station is New Application For Computing-Control

MILWAUKEE—

When an electric generating station ages and becomes a high unit cost producer, a utility is likely to relegate it to the role of a peaking station, to be brought on line only when loads exceed the normal capacity of the system. That means starting up and shutting down the station regularly, as often as several times a week. Because startup of an electric generating station requires a complicated procedure, it sounds like a good possibility for computing-control. When the startup has to be repeated frequently, the procedure is ideal for programming by a process control computing system.

This is the reasoning Gulf States Utilities Co. went through when the company took a look at its old Riverside Power Station in Lake Charles, La. The plant had reached a point where the cost of generating was almost too expensive even for a peaking plant. Faced with the dilemma of doing something drastic and expensive to cut generating costs or closing the plant and buying peak power elsewhere, Gulf States came up with a compromise: a relatively inexpensive computer control system to automate the startup and shutdown procedures and to optimize fuel consumption.

• **Newcomers**—To do this pioneering job, Gulf States chose a new team in the computer control field: a combine of Allis-Chalmers Manufacturing Co. and Consolidated Systems Corp. in which A-C recently acquired a half interest (CtE, Aug. '60, p. 44). The computer: the RCA 110 (Riverside is the first announced application.

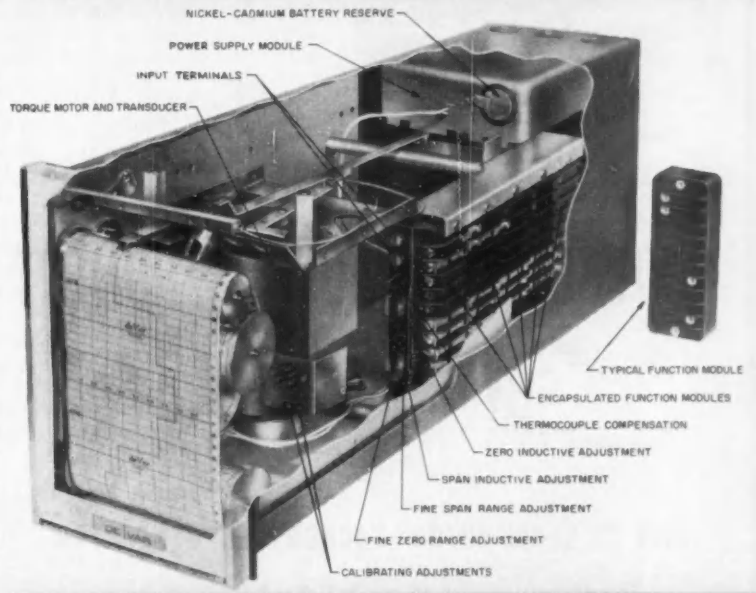
Chief objectives for the control system will be safe and efficient startup and shutdown of the plant. Secondary emphasis will be placed on fuel optimization, in contrast to the scheme for normal-load plants.

Modifications to the turbines (originally built by A-C) include the addition of wide range governors to control speed setting. Thermal expansion and bearing vibrations will be measured by transducers, and the reading will be logged by the computer. These signals, along with others from temperature detectors in journal and thrust bearings, hydrogen seals, and the generator, will be printed on trend recorders for visual observation by the operator.

• **Choosing the computer**—In choosing the RCA computer, A-C considered its speed, number of commands presently available, the more economi-

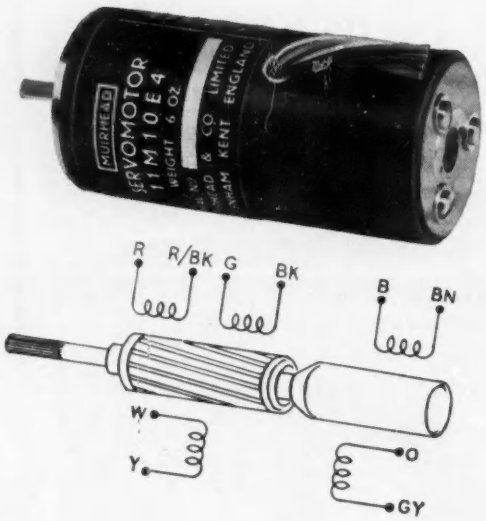
GENERAL KINETICS
DE VAR

NEW
MINIATURE
3 PEN RECORDER



DE | VAR SYSTEMS, INC.
494 GLENBROOK ROAD
GLENBROOK, CONNECTICUT
DA-4-1105

CIRCLE 153 ON READER SERVICE CARD 153



50:1
Output to
Null Ratio

ANOTHER PRECISION INSTRUMENT

BY MUIRHEAD

SIZE 11 SERVOMOTOR - TACHOMETER GENERATOR

This latest addition to the Muirhead range of servo components, has an output at 1000 rev/min to fundamental null ratio exceeding 50:1, thus making it first choice for use in high performance servos. Other parameters are as follows:

Motor		*Generator*	
Stall Torque	0.63 oz. in	Output Voltage	0.6V/1000 rpm
No Load Speed	5600 rev/min	Fundamental Null	12mV
Input Power	3.5 watts	Total Null	19mV
Time Constant	0.017 sec	Phase Shift	6 degrees
Overall Length	2.265 ins	Weight	6 ozs

Order one for your prototype now

Full data sheet available

MUIRHEAD

Precision Electrical Instruments

MUIRHEAD INSTRUMENTS INC.
441 Lexington Avenue, New York 17, N.Y., U.S.A.
Telephone: Murray Hill 2-8131
MUIRHEAD INSTRUMENTS LIMITED. Stratford, Ontario, Canada
Telephone: 271 — 3880
MUIRHEAD & CO. LIMITED, Beckenham, Kent, England
Telephone: Beckenham 4888

483

cal packaging and accessibility of its memory store, and its priority interrupt feature.

The computer will also be able to decide when to use an abbreviated startup procedure if the plant has been operating only a short time before, so that it is still hot.

Allis-Chalmers calls its new computer control system Systemation and expects it can be modified for application in other process systems. Consolidated Systems Corp. will design the instrumentation and data handling equipment for the setups.

CSC is banking strongly on utilities for application of computing-control. But the AC-CSC combination, in concert with CSC's other parent firm, Consolidated Electrodynamics Corp. (itself a subsidiary of Bell & Howell Co.), is also attempting to get moving on the design of new computer controlled process plants. CSC still intends to stay on its own in the petrochemical field.

Control Theorists, OR Men Make Peace at Conference

BRUSSELS, BELGIUM—

With a turnout of experts from 16 countries reaching 300—three times that anticipated—Europe's first in a series of specialized control application seminars was a rousing success. The conference, the International Seminar on Analog Computation Applied to the Study of Chemical Processes, was organized by Belgium's Institute de Regulation et d'Automatissme. Foremost among the important products of the conclave was a meeting of the minds between the advanced control theorists and the proponents of operations research.

Informal discussions caused leaders of the two groups to wonder if they were striving after the same goals of mathematical models of processes but using different approaches and terminology. Conference attendees began to ask just how much common ground there was between operational research statistics and control theory.

Grist for the mill came from Cambridge University's J. K. Lubbock. In a paper describing plant mathematical models, Lubbock's approach to orthogonal systems held out promise of automatic setting of the model equation coefficients to give the best fit between model and plant.

• **Same goals, different means**—Comment on Lubbock's approach came from the operational researcher's view-

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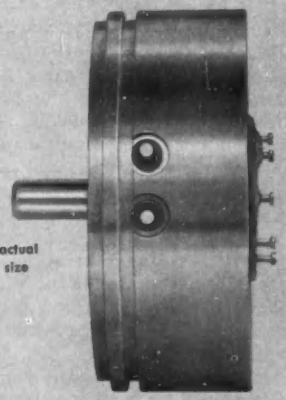

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point of L. Gallon, British Petroleum Ltd. Research Dept. He pointed out the similarity between Lubbock's method and the standard operations research multivariable analysis, like principal component analysis, canonical correlation, and factor analysis. Gallon called for a closer look at the apparent closeness of approach, saying, "In generating mathematical models, statistical techniques and control theory appear to be rapidly converging, and we must see that we all talk the same language."

In the two and a half days of sessions, the 21 papers presented ranged from the trivial to the highest levels of mathematics. Application papers, though accounting for half the papers, revealed few on-line analog computer control setups yet in Europe.

Arousing most practical interest was a method described by A. W. O. Firth of England's Redifon Ltd. Firth demonstrated how to use standard analog computer building blocks to solve linear programming problems.

Louis Allis Takes First Step in Electronics

The Louis Allis Co., old line Milwaukee electrical equipment builder, has made its first move into the electronics field with the purchase of the Dynapar Corp. of Skokie, Ill. The acquisition is the first step in a long range diversification program for the company, according to President John W. Allis.

Dynapar is an eight-year old firm that specializes in custom electronic equipment such as digital controllers, speed indicators, and other equipment used in primary metal, rubber, and other process industries. Louis Allis intends to market the Dynapar line not only as separate components but also in conjunction with Allis adjustable speed drive equipment.

Collins to Link EDP Customers to Central Computer

Collins Radio has formed a division to provide electronic data processing services to industry. The company will use its Kineplex data transmission equipment to tie a chain of subscriber stations directly to a central data processing center at Collins' Cedar Rapids, Iowa, headquarters.

First step for the new Communications and Data Processing Div. will be to tie together all Collins divisions and

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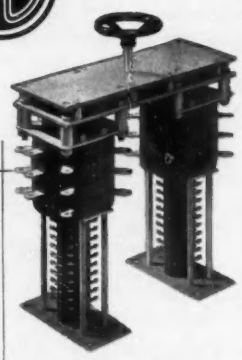
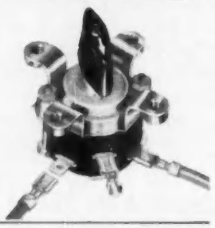
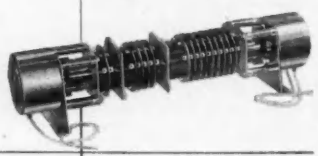
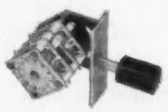
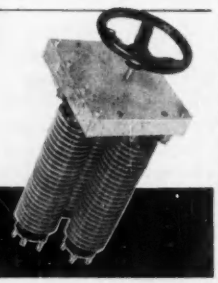
Single-control tandem pair; snap-action; 7 × 19 inches × 20 inches behind panel. 75 lbs. approx.	200 amps. 500 v. a-c 6-pole, triple-throw; 30 amps. 500 v. a-c 20-pole, triple-throw.	
Quick-connect terminaling for snap-on wiring; 3¼ inches diameter, 3 inches behind panel. 8 oz. approx.	10 amps. 125 v. a-c single-pole 4-position; snap action.	
2-way drive by 6-volt solenoids; 3⅞ inches diameter, 18½ inches long. 12 lbs. approx.	10 amps. 125 v. a-c 34 poles, 2 positions.	
High-current low-voltage tap switch; 10¾ × 10¾ inches, 14 inches behind panel. 25 lbs. approx.	150 amps. 6 v. a-c 6-pole 12-position.	
Lever-actuated miniature switch; 1¼ × 1¾ inches. 1¼ inches behind panel. 2 oz. approx.	3 amps. 125 v. a-c 4-pole 3-position.	
3-gang, gear-drive single-control switch; 6⅝ × 7⅛ inches × 14 inches behind panel. 25 lbs. approx.	5 amps. 125 v. d-c 75 poles 2 positions.	

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WHAT'S NEW

subsidiaries as the first subscribers. The first link—between the Collins subsidiary in Toronto and Cedar Rapids—has been completed and is in operation. This model system will comprise the organization's entire communication and data processing facilities. Automatic switching and control equipment will monitor intra-company voice, teletype, and data communication using wire lines and point to point and air to ground radio.

Additional links with the central EDP facility will tie in subscriber stations in Los Angeles, Dallas, Washington, D. C., New York, and Kansas City. These links will be made by wire line using Kineplex. On line, real-time computing capability will be made available to outside customers within two years.

OPW Merged Into Dover Corp.

A Cincinnati manufacturer of specialty valves, the OPW Corp., has been merged into Dover Corp. of Washington. Subject to stockholder approval, the deal calls for the exchange of $1 million in cash and 247,500 shares of Dover common stock valued at close to $4.5 million.

OPW will be a division of Dover with its present management. The OPW Div. manufactures valves and other products for the petroleum and chemical markets. The OPW-Jordan Div. produces temperature regulating and control valves.

News of Other Companies In the Control Field

American Electronics, Inc. and Electronic Specialty Co. both of Los Angeles have announced that they are negotiating to consolidate. Combined sales of the two firms are curerntly at the annual rate of $40 million. American Electronics makes a range of equipment including electromechanical actuators, servosystems, and computer components. Electronic Specialty produces avionic devices and precision power supplies.

Brooks Instrument Co., Inc., Hatfield, Pa., has formed a European manufacturing subsidiary to produce Brooks' line of rotameter-type flow instrumentation, level controls, and other components. The new firm, Brooks Instrument Nederland N. V., will be located in Veenendaal, Neth-

erlands, and will be a wholly owned subsidiary of Brooks Instrument Co., S. A., a sales company previously formed in Switzerland.

International Rectifier Corp. of El Segundo, Calif., has joined with Piemontese Sviluppo Industriale S.p.A., one of Italy's largest holding companies, to form a multimillion dollar semiconductor manufacturing facility in Europe. First plant will be set up near Turin.

Shafford Electronics & Development Corp. is a new company in Santa Monica, Calif., that will engage in the design and manufacture of control systems for industry and the military. President of Shafford is Clifford A. Shank, formerly with AiResearch Manufacturing Co.

Ampex Corp. and Telemeter Magnetics, Inc. shareholders have approved a merger of the companies at special sessions held in the respective company offices in Redwood City and Culver City, Calif. Directors had previously approved the plan which calls for the exchange of one share of Ampex for two of TMI; Ampex is the surviving corporation.

Hydro-Aire Co., part of Crane Co.'s Systems and Control Group, has acquired the line of analog to digital converters formerly produced by the Jones and Wettlaufer Engineering Corp. of Los Angeles.

Bendix Corp. has relinquished its holdings in Elliott-Automation Ltd., the English control manufacturing complex in which Bendix had originally held a one-third equity interest, reduced to 7½ percent.

Varian Associates and Eastern Industries, Inc. have reached a preliminary form of an agreement for the merger of Eastern into the Palo Alto, Calif., company. The present plan calls for one share of Varian to be exchanged for three of Eastern's shares.

American Radiator & Standard Sanitary Corp., New York, has acquired the Rochester Manufacturing Co. to be a part of American-Standard's Detroit Controls Div. The acquisition involved the exchange of 125,000 shares of stock. Rochester produces liquid level, pressure, and temperature indicating instruments.

Chance Vought Corp. is the new name for Chance Vought Aircraft, Inc. as of Dec. 31. Change reflects the diversification achieved by the Dallas firm.

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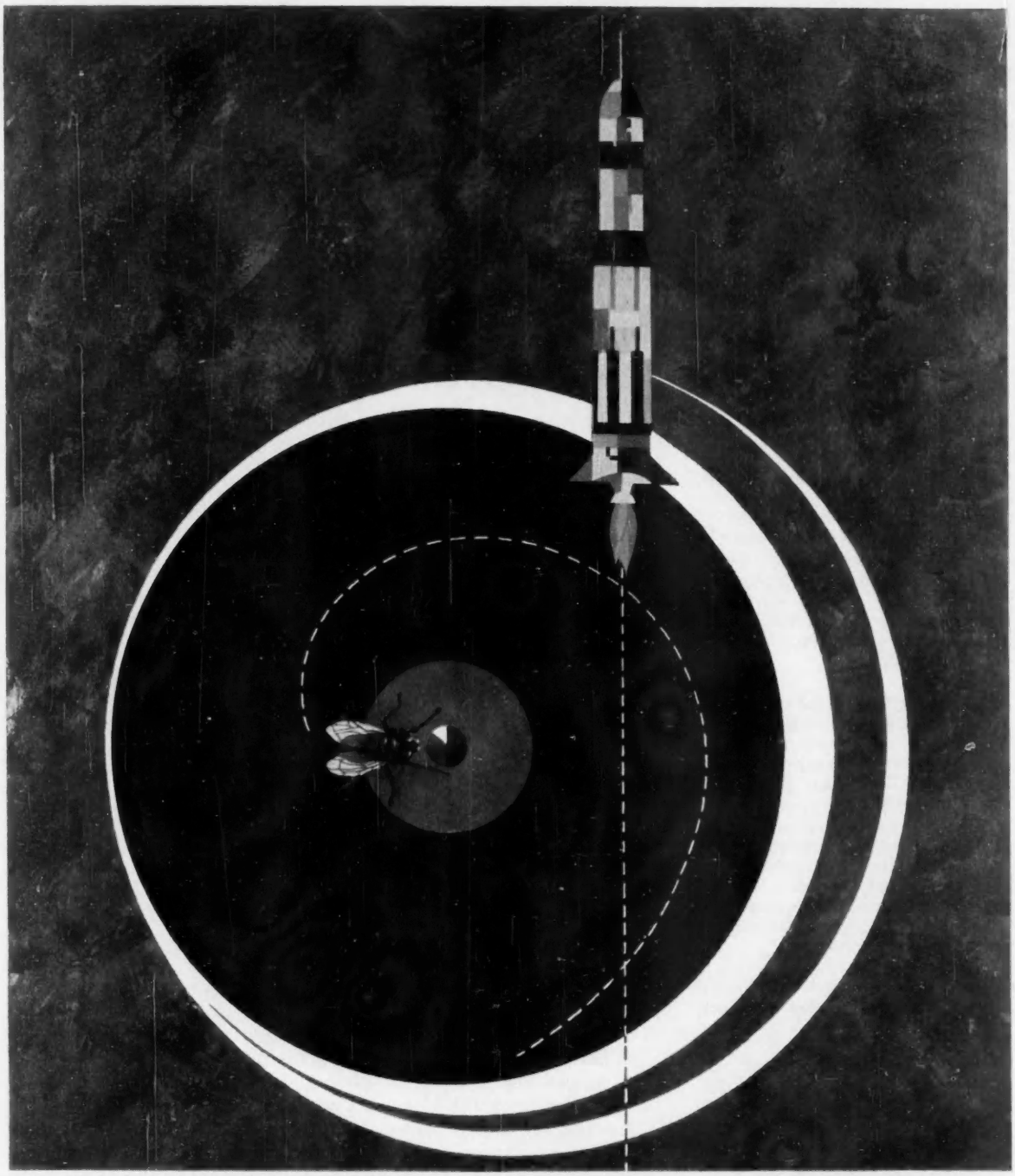

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IMPORTANT MOVES BY KEY PEOPLE

Sperry Rand Names Halpert To Manage Phoenix Div.

Percy Halpert has been appointed to the position of division manager of Sperry Rand Corp.'s Phoenix Div. Since 1937 Halpert has been with Sperry in various capacities. Before his new appointment, he was chief of the company's aeronautical equipment engineering at Great Neck, N. Y.

Halpert holds a MSEE degree from City College of New York and has accumulated 26 patents during his years of research and development activity. The activity he will head specializes in flight equipment including automatic controls, gyros, guidance systems, and pilotless flight systems. He will also be responsible for Sperry's radio and radar facility in Sunnyvale, Calif.

Myers Heads Hewlett-Packard Components Div.

The former manager of the Electrical Engineering section of Hewlett-Packard Co.'s Manufacturing Engineering Dept., William D. Myers, will manage the new Precision Components Div. of the Palo Alto, Calif., company. Myers, a 16-year company veteran, was formerly with RCA and Packard Bell. He is a senior member of the IRE and a graduate of Stanford University.

The new division will coordinate the company's activities in developing and producing special components. These include such devices as silicon diodes, photoconductors, and semiconductors. There will be three principal research and development sections: quartz crystals, diodes and transistors, and solid state chemistry.

Berkner To Head IRE; V-P's Also Named

The Institute of Radio Engineers, the world's largest engineering society (85,000 members), has chosen Lloyd V. Berkner as its president for 1961. Berkner, president of Associated Universities, Inc., will preside with the assistance of two vice-presidents, J. F. Byrne and Dr. Franz Ollendorff.

Berkner, who succeeds Ronald L. McFarlan in the top post, has headed Associated Universities since 1951. The educational institution operates Brookhaven National Laboratory, the National Radio Astronomy Observatory, and other research facilities. Berkner has held many offices and advisory positions in government, industry, and education, including chairmanship of the Space Science Board of the National Academy of Sciences and consultant to the President's Science Advisory Board.

Following the IRE's year-old policy, the two vice-presidents come from North America and abroad, respectively. Byrne is manager of the Riverside Research Laboratory of Motorola, Inc. Dr. Ollendorff is a research professor at the Technion-Israel Institute of Technology, Haifa.

Wolfe Joins Borg-Warner As Manager of Engineering

A specialist in instruments, Dr. C. M. Wolfe will supervise transducer research and development programs as the head of transducer engineering at Borg-Warner Controls Div. of Borg-Warner Corp., Santa Ana, Calif. These programs will include refinements in existing transducers as well as new product development.

For the past 16 years Dr. Wolfe has been in the research and development fields of missile systems and rocket motors and instrumentation.

He holds a PhD in electrical engineering from California Institute of Technology and was a research specialist at United Electrodynamics before moving to Borg-Warner Controls. For seven years he taught at the University of Washington. He holds 12 patents and has developed 30 instruments for use with missile systems and rocket motors.

Other Important Moves

John L. Hawk has joined CEIR, Inc., as director of its New York Research Center. Formerly he was industry area manager of IBM's advanced Systems Development Div. He is slated to direct the computing ac-

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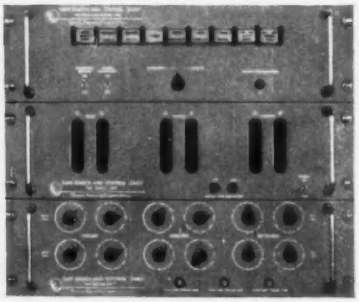

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tivities of the center, which is currently equipped with an IBM 7090 data processing system. He'll also manage the research efforts of the CEIR unit.

Charles D. Brown has taken the post of president of MB Electronics, New Haven, Conn., a div. of Textron Electronics, Inc. Formerly Brown was an executive of the General Electric Co. He replaces George H. Mettler who has become vice-president of Textron, Inc.

Dr. I. Melville Stein is the president of the Foundation for Instrumentation Education & Research for 1961. Melville is the president of Leeds & Northrup Co.

Robert H. Packard has taken the job of Chief Engineer of Power Sources, Inc., Burlington, Mass. With more than 25 years of electronics experience, Packard has served with many firms in the Boston area. He has been with Power Sources since May

Henry C. Jones, former executive vice-president and director of operations, has been elected president of The Electrada Corp. of Beverly Hills, Calif. Jones joined Electrada in July after 18 years with Convair.

David H. Brown is the new general manager of the Bendix-Pacific Div. of the Bendix Corp., No. Hollywood, Calif. Brown started with Bendix-Pacific in 1938 as a draftsman. Before his latest appointment he had been assistant general manager.

Hans-Joachim Kunzke has been appointed design engineer for computer and electronic data processing products of the Clary Corp. Before coming to the San Gabriel, Calif., firm, Kunzke did computer development work for West German companies including Olympia AEG, Grundig, and C. Lorenz A.G.

Duncan N. MacDonald has been named director of engineering for the Electro-Data Div. of Burroughs Corp. in Pasadena, Calif.

David C. McNeeley, manager of the Helipot Div. of Beckman Instruments, Inc., has been elected president of the Precision Potentiometer Manufacturers' Association. The PPMA is a new organization formed to establish standards for the precision potentiometer industry.

COMING NEXT MONTH

- **What Industry Thinks of Fire-Resistant Fluids**
  Experts in fluid companies, equipment makers, users, and insurance give their opinion.

- **Two vs Three Gyro Guidance Platforms**
  How platforms compare that use one degree and two degree of freedom gyroscopes.

- **Accurate Valve Sizing for Flashing Liquids**
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315	326	337	348	359	370	381	392	403	414	425	436	447	458	469
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475	486	497	508
476	487	498	509
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478	489	500	511
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482	493	504	515
483	494	505	516
484	495	506	517

Name _____ Title _____

Company _____

Address _____ City _____ Zone _____ State _____

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1	15	29	43	57	71	85	99	113	127	141	155	169	183	197	211	225	239	253	267	281	295
2	16	30	44	58	72	86	100	114	128	142	156	170	184	198	212	226	240	254	268	282	296
3	17	31	45	59	73	87	101	115	129	143	157	171	185	199	213	227	241	255	269	283	297
4	18	32	46	60	74	88	102	116	130	144	158	172	186	200	214	228	242	256	270	284	298
5	19	33	47	61	75	89	103	117	131	145	159	173	187	201	215	229	243	257	271	285	299
6	20	34	48	62	76	90	104	118	132	146	160	174	188	202	216	230	244	258	272	286	300
7	21	35	49	63	77	91	105	119	133	147	161	175	189	203	217	231	245	259	273	287	301
8	22	36	50	64	78	92	106	120	134	148	162	176	190	204	218	232	246	260	274	288	302
9	23	37	51	65	79	93	107	121	135	149	163	177	191	205	219	233	247	261	275	289	303
10	24	38	52	66	80	94	108	122	136	150	164	178	192	206	220	234	248	262	276	290	304
11	25	39	53	67	81	95	109	123	137	151	165	179	193	207	221	235	249	263	277	291	305
12	26	40	54	68	82	96	110	124	138	152	166	180	194	208	222	236	250	264	268	292	306
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14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308

NEW PRODUCTS & BULLETINS

309	320	331	342	353	364	375	386	397	408	419	430	441	452	463	
310	321	332	343	354	365	376	387	398	409	420	431	442	453	464	
311	322	333	344	355	366	377	388	399	410	421	432	443	454	465	
312	323	334	345	356	367	378	389	400	411	422	433	444	455	466	
313	324	335	346	357	368	379	390	401	412	423	434	445	456	467	
314	325	336	347	358	369	380	391	402	413	424	435	446	457	468	
315	326	337	348	359	370	381	392	403	414	425	436	447	458	469	
316	327	338	349	360	371	382	393	404	415	426	437	448	459	470	
317	328	339	350	361	372	383	394	405	416	427	438	449	460	471	
318	329	340	351	362	373	384	395	406	417	428	439	450	461	472	
319	330	341	352	363	374	385	396	407	418	429	440	451	462	473	

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474	485	496	507	
475	486	497	508	
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483—Economics in Control, 50 cents
482—Static Switching Devices, 50 cents
480—Applying Control Timers, 50 cents
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477—Basic Data on Process Control Systems, 50 cents
476—Three Ways to Simulate Dead Time, 15 cents

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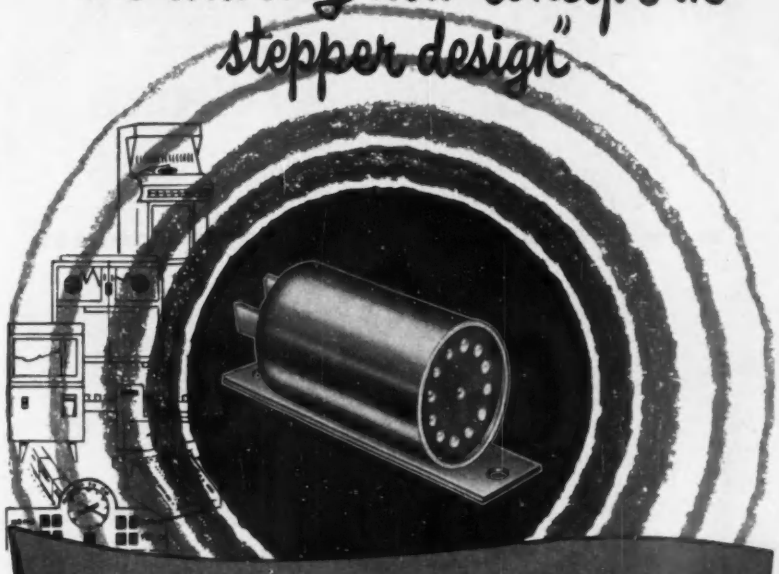
CONTROL BITS

Shipments of electrical measuring instruments by U. S. manufacturers during the first three months of 1960 amounted to 1,037,431 units, valued at $35,213,688. The figure was obtained from a quarterly survey of production capabilities by the Scientific, Motion Picture and Photographic Products Div., Business and Defense Service Administration, U.S. Dept. of Commerce. This was the first such survey ever made in the electrical instrument industry. Commerce expects to make subsequent ones.

•

Continuous generation of coherent light in an optical maser may be possible with two new crystals developed by researchers at IBM. The new materials, trivalent uranium in a calcium fluoride lattice and divalent samarium in the same kind of lattice, have an energy level, slightly above ground state, to which stimulated ions can retreat. As a result the generation of coherent light requires fewer ions in the energized condition. The new material should need only 1/500, the pumping power demanded by ruby crystal light masers.

"an entirely new concept in stepper design"



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● Now—a radical departure in stepper design provides new opportunities for applying the stepping relay principle over a far wider range than ever before.

1. **High Contact Rating.** 3 amps resistive, 1 amp inductive (50% P.F.) made possible by contactor action, dual make-break, positive circuit isolation contact mechanism. A revolutionary development, the Rotomite stepper eliminates wiping contacts, bridged circuits and, in most applications, slave relays.
2. **Continuous Duty**—from 3 to 230 v.d.c.
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5. **Life:** Well in excess of 1,000,000 operations.
6. **Size:** 2" long and 1⅛" in diameter. Weight: approx. 4 oz. Cost? Incredibly low! Write on your business letterhead for quick sample service and detailed information about the "Rotomite" midget stepper.

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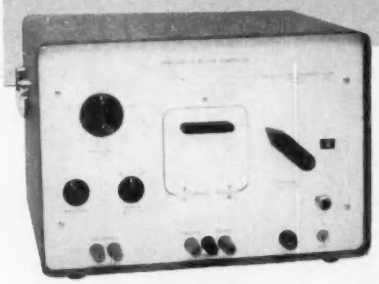

THE
tensor
5846 ARBITRARY
FUNCTION GENERATOR

$495.00 F.O.B.
Brooklyn, N.Y.

In addition to producing standard sine, triangular and square waveforms, the Model 5846 can generate arbitrary functions as desired by changing cam shapes.

Specific waveshapes are quickly formed by inserting appropriate cams into the instrument. Cams for desired functions are available from the factory, or can be easily constructed from enclosed instructions.

Tensor's Arbitrary Function Generator comes equipped with two cams... one for sine wave... one for triangle wave. The square wave, at the function frequency, is of adjustable phase and symmetry. It is always available regardless of the function being generated.

APPLICATIONS:

The Tensor Arbitrary Function Generator is extremely flexible because of (1) the infinite variety of waveforms that can be produced, (2) the wide frequency range and (3) provision for suppressed carrier modulations. Listed below are typical applications:

AC or DC servo testing
Vibration machine programming
Medical electronics
Input to analogue devices
Process control testing
Any application where electrical simulation of mechanical, physiological, biological or hydraulic functions is desired.

SPECIFICATIONS:

Frequency Range: .001 to 10 cps in four ranges

Output Voltage: 10 volts peak to peak, adjustable

Load Requirements: 10K or greater

Output Function: Cams supplied for sine and triangle waveforms

Sine Wave Distortion: 3% harmonic

Triangle Wave Distortion: ±3% deviation from a straight line

Power Requirements: 50 watts at 115 VAC 60 cps

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BULLETINS AND CATALOGS

(400) MISSILE INSTRUMENTATION. Computer Systems, Inc. Form 80-350-TC-3, 5 pp. Report describes typical instrumentation chain for missile-range control application. Details cover vehicle tracking, plotting of tracking data, and control of target acquisition equipment.

(401) ROTARY ACTUATORS. Houdialle Industries, Inc. Catalog HYD-1, 16 pp. Covers the design, operation, and specifications on a complete line of precision hydraulic rotary actuators for industrial applications. Complete torque/pressure curves are provided for the various size actuators.

(402) GAS SURVEY RECORDER. Fischer & Porter Co. Catalog 35-1543, 4 pp. Reviews the basis for scientific gas demand studies and describes how survey costs can be minimized by use of an automatic gas survey recorder.

(403) ACCELEROMETER BULLETIN. Schaevitz Engineering. Bulletin B4, 4 pp. Illustrates and describes nine series of linear and angular accelerometers currently available from this manufacturer.

(404) CONDENSED TUBE CATALOG. Amperex Electronic Corp. Catalog No. CC860, 26 pp. Contains descriptions and basic specs on a full line of electronic tubes: cold cathode trigger tubes, audio tubes, ignitrons, indicator tubes, klystrons, magnetrons, power tubes, photomultiplier tubes, and many others.

(405) BATCH WEIGHING SYSTEMS. Gilmore Industries, Inc. Bulletin B-100, 20 pp. Deals with both manual and automatic electric batch weighing systems. Applications discussed range from low cost, short run installations where the formula is frequently varied all the way to complicated production batch weighing runs. Details on features and operation are included, along with diagrams and photos of the systems.

(406) CONTROL PILOT DEVICES. General Electric Co. Bulletin GEA-7392, 8 pp. Describes this company's line of control pilot devices, which include pressure and vacuum switches, pressure governors, plugging and antiplugging switches, float switches, pilot switches, and manual reversing switches. Advantages of each product are listed along with ratings and nomenclature charts.

(407) ELECTRONIC PROCESS CONTROLS. Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div. Bulletin No. 10, 8 pp. Brochure describes the Robertshaw-Microsen closed-loop, all electronic process control systems, capacitance actuated level detection and control instruments, and Vibraswitch malfunction detectors. Technical bulletin references are also cited.

(408) SPEED MEASUREMENT. The Meriam Instrument Co., Electronic Div. Bulletin No. 2,000, 6 pp. Illustrates instrumentation designed to provide an accurate and trouble-free method for measuring, indicating, or recording most rotative motion. Easy-to-read specification tables accompany recommendations for the application, mounting, and coupling of each model.

(409) SHIPBOARD SPEED CONTROL. General Electric Co. Bulletin GEA-7202, 8 pp. Explains design flexibility of a line of ac reactor speed controls which permit precise speed regulation of gantry and rotating cranes, cargo winches, windlasses, and capstans with countertorque and regenerative braking. Bulletin also describes stepless static control over an entire speed range from a single master switch with no dc conversion equipment.

(410) THERMAL SWITCHES. Control Products, Inc. Brochure, 8 pp. Describes 11 bimetal thermal switches. Contains a discussion of the bimetal principle and gives detailed technical information on applications, specifications, standard variations, and modifications.

(411) RADIATION PYROMETERS. Servo Corporation of America. Technical Bulletin TB 1372, 4 pp. Covers the company's line of industrial infrared radiation pyrometers for permanent installation or portable use. Provides complete specifications on the pyrometer head and control indicator.

(412) TAPE PROGRAMMED ANALYSIS. Mine Safety Appliances Co. Bulletin No. 0714-5, 4 pp. Describes a new precision gas chromatograph and its tape programmed control unit. Photos and diagrams illustrate the controller in a locked dust-proof housing, and the analyzer in an explosion-proof housing.

(413) DRY MATERIALS HANDLING. Flo-Tronics, Inc. Bulletin ECD1-6008, 4 pp. A large isometric drawing of a complete dry-bulk materials handling system indicates the many points at which controls are required. Text describes the advantages of the company's centrally located control systems for use with this and similar bulk handling systems.

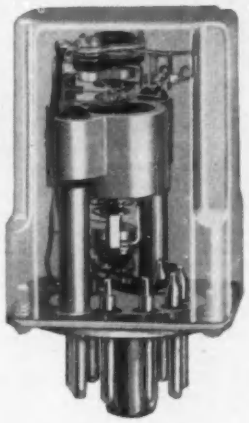
(414) TRANSMITTER-RECEIVER. Friden, Inc. Bulletin SP 8709, 12 pp. Describes the advantages of the company's Dual Teledata Taped Transmitter-Receiver in new tape operated communications equipment. Booklet contains several views of the equipment.

(415) SCOPE PLUG-IN UNITS. Tektronix, Inc. Bulletin, 32 pp. Gives a detailed presentation of all 16 presently available letter-series plug-in units for Tektronix oscilloscopes. Includes complete specifications and performance characteristics with waveform patterns and other illustrative material.

(416) HOT GAS GYROS. Instrument Div., Lear, Inc. Bulletin GR 323, 4 pp. Deals with the design and performance characteristics of two-degree-of-freedom gyros, driven by hot gasses, and used to provide displacement reference for missiles during short term flights.

(417) SERVOAMPLIFIERS. Magnetic Amplifier Div., The Siegler Corp. Catalog S-1169, 16 pp. Contains specifications and application data on the company's complete line of servoamplifiers for both military and industrial uses. Products covered include push-pull saturable transformers, all magnetic and transistorized-magnetic amplifiers, and miniaturized amplifiers, plus a line of transistor servoamplifiers.

(418) PORTABLE OSCILLOSCOPES. Tektronix, Inc. Catalog, 16 pp. Gives a detailed presentation of the seven available Tektronix oscilloscopes with 3-in.



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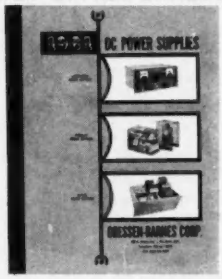

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cathode ray tubes, including rack mounting models. Contains complete specifications, performance characteristics, and pertinent illustrations.

(419) RECORDERS & INDICATORS. Minneapolis-Honeywell Regulator Co. Catalog C15-1a, 48 pp. New recorder catalog highlights modular design features of the company's ElectroniK recorders and indicators. Sections cover strip chart recorders, circular chart recorders, precision indicators, primary measuring elements.

(420) GUIDANCE SYSTEMS. Kearfott Div., General Precision, Inc. Bulletin, 8 pp. Discusses the applications and performance of the company's systems and components for inertial guidance applications. Products covered include a light weight inertial autonavigator and its stable platform, floated rate integrating gyros, electronic integrators, amplifiers, display and control units, etc.

(421) T'COUPLE SELECTOR SWITCHES. Thermo Electric Co., Inc. Catalog 24-2, 4 pp. Deals with the design and operation of compact multipoint thermocouple selector switches. Details cover rotary switches with 6, 12, or 24-point capacity; key switches for up to 144 points; and pushbutton models for up to 72-point.

(422) FILLED THERMAL SYSTEMS. Minneapolis-Honeywell Regulator Co. Specification S-690-1a, 12 pp. Covers bulbs, tubing, and fittings for filled system thermometers. Specification sheet gives details concerning sizes, lengths, materials, etc. for bulbs and tubings of gas, mercury, and vapor-actuated thermal systems.

(423) TUNNEL DIODE APPLIED Sperry Semiconductor Div., Sperry Rand Corp. Bulletin No. 2106, 4 pp. Deals with the operation and applications of tunnel diodes. Bulletin discusses the significant characteristics of tunnel diodes and their application in amplifiers, oscillators, and high speed switches.

(424) PROXIMITY SWITCHES. Electro Products Laboratories, Inc. Form EDPS-80, 8 pp. Provides a complete description of the firm's entire proximity switch line as well as the basic technical information required to enable a prospective user to determine the model best suited to his needs. Booklet also features a control amplifier selection guide which simplifies matching of the control amplifier with specific applications.

(425) ON-STREAM ANALYSIS. Industrial Nucleonics Corp. Bulletin CA-860, 12 pp. Bulletin describes the principles upon which continuous, noncontacting measurement of fluids in pipes is based. Includes sections devoted to the economic justification for this type of equipment, descriptions and drawings of system components, as well as application data.

(426) REGULATED POWER SUPPLY. Krohn-Hite Corp. Bulletin 201, 4 pp. Offers details on a new highly regulated transistorized dc power supply. Brochure fully describes the instrument's unusual features and design innovations and includes complete technical specifications for all available models.

ABSTRACTS

Three on computing-control

The session on Optimum Control of Chemical Processes at the Joint Automatic Control Conference, Sept. 9 1960, presented possible solutions to the generalized chemical processing model developed by Williams and Otto of the Monsanto Chemical Co. for the investigation of computer control. (AIEE Paper No. CP-60-119).

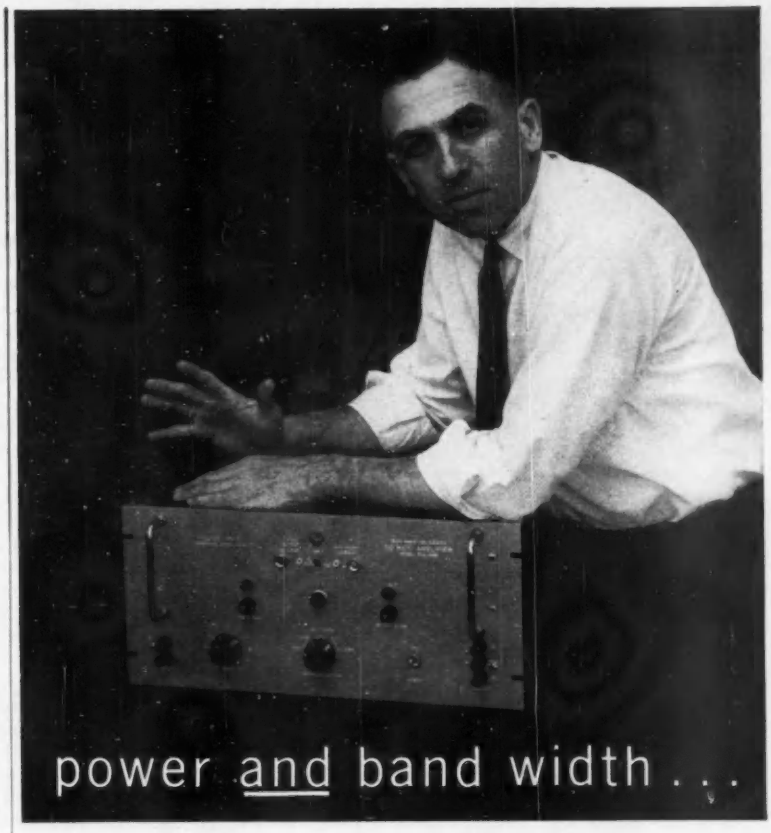
Three papers were presented:

1. **"Dynamic Solution to a Generalized Chemical Processing Model", by R. E. Boydston, Information Systems, Inc. (AIEE Paper No. CP-60-970).**
2. **"Considerations in the Design of a Dynamic Control System for Generalized Chemical Processing Model Considered as a Nonlinear System", by A. E. Beecher and L. A. Gould, Electronic Systems Laboratory, Massachusetts Institute of Technology. (Not preprinted.)**
3. **"Dynamic Optimization and Control of a Stirred Tank Chemical Reactor", by W. Kipiniak and L. A. Gould, Electronic Systems Laboratory, Massachusetts Institute of Technology. (AIEE Paper No. TP-60-982.)**

These reports emphasize the extreme complexity of even the simplest chemical processing systems when considered as objects for dynamic optimization and control. As a result, authors confined their attentions to the reactor and in effect ignored the remainder of the plant. The reactor is the most important piece of equipment in the model process.

R. E. Boydston discussed the application of the dynamic control technique proposed by Kalman and associates to a linearized version of the generalized model. His object was to use a digital computer as part of a plant control system to reduce to a minimum the time the reactor is operating off the optimum operating point after an upset in feed conditions.

Boydston derived the necessary mathematical model to accomplish this and estimates that a machine of the capability of the Panellit 609 would require about 1,000 memory words and approximately 1/30th of the available computing time to monitor and control the operation of a reactor such as described in the original model. Thus a single computer could handle several reactors in parallel with a scheme as proposed here.



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ABSTRACTS

The papers by Gould and associates tackled the problem of the optimization of the control of the reactor considered as a nonlinear system. Beecher and Gould discussed the possibilities of a dynamic optimization by digital computer control. By the methods of variational calculus they derived the set of Euler-Lagrange equations necessary to solve for the optimum correction path for the reactor to follow after an upset. Since the solution of the Euler-Lagrange equations is itself unstable, the set of equations must be continually resolved for the existing reactor conditions and a new path calculated before the last has reached its point of divergence. Such a calculation with 14 equations necessary to specify the reactor and its control is impossible in anything like real time with existing equipment. Therefore Beecher showed the applicability of his method by a simpler example.

Kipiniak and Gould proposed a solution to the difficulty encountered by Beecher by solving the 14 dynamic optimization equations off-line on available computers for a variety of initial conditions. From these solutions a table of optimum controller actions to be taken for any possible reactor state away from the optimum condition is computed. By a table-lookup operation, a relatively simple control computer can then provide sophisticated dynamic optimized control of the process.

T. J. Williams

500-deg C magamp

From "High Temperature Magnetic Amplifiers (400 Cycles per Second)", by Westinghouse Electric Corp. for Wright Air Development Division, U.S. Air Force. Available from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D. C. as PB 161762, 121 pp., $2.75.

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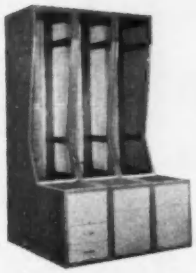

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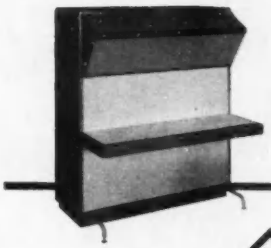

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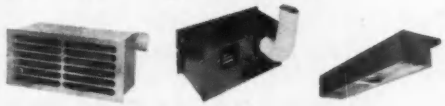

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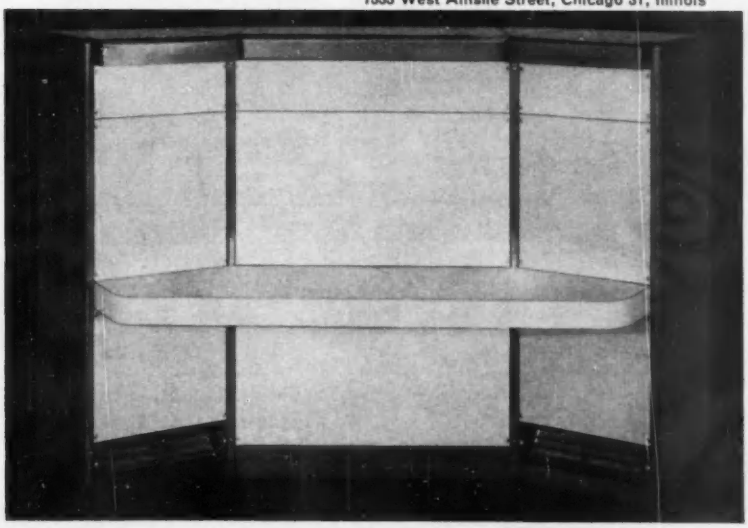

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NEW BOOKS

Sticks to Laplace

HANDBOOK OF LAPLACE TRANSFORMATION, *F. L. Nixon. 115 pp. Published by Prentice-Hall Inc., Englewood Cliffs, N. J.* $6.00.

Reversing the trend apparent in many new books on over-all mathematics for the control engineer, the author of this handbook has selected one useful topic, covered it in good detail, and done it well. The author's preface echoes some of this reviewer's thoughts on the book, so it is fitting to quote Mr. Nixon's words:

"In recent years there has been widespread usage of linear differential equations to describe engineering and physical problems. Laplace transformation techniques have thus become an indispensible tool for engineers, mathematicians, and physicists, and this Handbook is intended for these people. The extensive table of Laplace transform pairs located in Section VI is coded so that the user can find the exact pair he wants immediately. For those who are somewhat rusty on Laplace transform usage, Section V contains numerous examples which illustrate how the Laplace transform method is used. Section III contains the derivation of many Laplace transform theorems, and is written so that one who has not been exposed to Laplace transform theory can teach himself. The author has found that where many are familiar with determinants, few remember or use determinant manipulating techniques. Yet by using these techniques much time can be saved. Hence, a section is also included on determinants. Commonly used identities and root finding methods are also included for the convenience of the reader."

Regarding the detail with which the author treats the examples given in Section V, one example covers an electrical network that is described by three simultaneous differential equations when the switch is closed and two when the switch is opened. Nine pages are devoted to solving this problem, thus indicating that self-help readers can indeed follow through each of the needed solution steps.

For the table of Laplace transform pairs, the five-digit coding system is quite unique: the first digit indicates the power of s (of the polynomial fraction in s) which can be factored out of the numerator, the second indicates the order of s in the numerator, the third indicates the power

of s which can be factored out of the denominator, the fourth the number of real roots in the denominator distinct from zero, and the fifth the number of pairs of complex roots in the denominator. HRK.

Introductory treatment

STATISTICAL PROCESSES AND RELIABILITY ENGINEERING. *Dimitris N. Chorafas.* 438 *pp. Published by D. Van Nostrand Co., Inc., New York.* $12.75.

In this book the author explains the reasoning behind a broad range of statistical concepts and tools that have proven useful to engineers and mathematicians in industry and research.

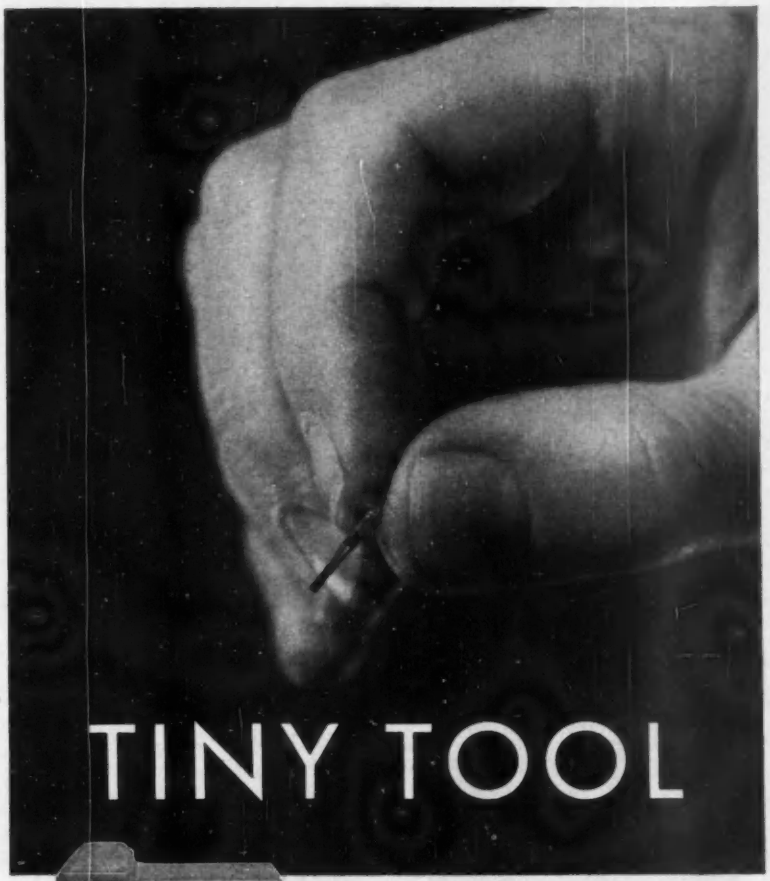
The book is organized into six major parts. The first gives an introduction to the mathematical tools of statistical techniques such as measurements, errors, statistical distributions, statistical inference, and others. The next covers statistical experimentation, including topics like analysis of variance, Latin squares, confidence limits, and factor analysis. The third part treats stochastic processes and probability theory in relationship to symbolic logic and the algebra of sets. The Monte Carlo method, statistical independence, and queuing theory are among the topics considered.

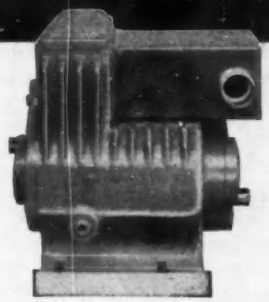
A section on information processes introduces some of the basic concepts of cybernetics, transmission, noise, and information theory. The fifth section deals with the very practical subject of quality control in terms of inspections, samplings, OC curves, as well as some special topics. The last section discusses reliability engineering in the light of the statistical methods presented earlier. It is brought out that satisfactory reliability requires a system design with all components having nearly equal life expectancy.

For a book of this size, the range of topics is quite impressive. However, there is not sufficient detail for the book to be considered a text for beginners in this field, nor is the presentation such that the volume would serve as a handbook. A lack of adequate references prevents the reader from exploring the various topics more thoroughly once his interest has been aroused by the introductory treatment.

In summary the book furnishes an introduction for the manager or engineer desiring a familiarity with the increasingly important topics associated with statistics. The book would also be of interest to specialized workers wanting a broader view of the applications of statistical methods.

Marvin P. Pastel
U. S. Naval Postgraduate School





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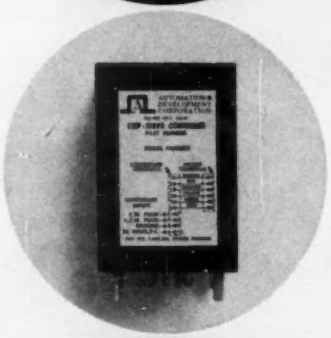

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MEETINGS

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Symposium on Thermoelectric Energy Conversion, sponsored by IRE, AIEE, and others, Statler Hotel, Dallas, Tex. Jan. 8-12

Seventh National Symposium on Reliability and Quality Control, sponsored by IRE, AIEE, ASQC, EIA, Bellevue-Stratford Hotel, Philadelphia, Pa. Jan. 9-11

16th Annual Symposium on Instrumentation for the Process Industries, Texas A&M College, College Station, Tex. Jan. 26-28

American Institute of Electrical Engineers, Winter General Meeting, Statler-Hilton Hotel, New York Jan. 30-Feb. 3

FEBRUARY

Institute of Radio Engineers, Second Winter Military Electronics Convention, Biltmore Hotel, Los Angeles, Calif. Feb. 1-3

Eighth Annual International Solid-State Circuits Conference, sponsored by IRE, AIEE, and University of Pennsylvania, University of Pennsylvania Campus and Sheraton Hotel, Philadelphia, Pa. Feb. 15-17

Petrochemical and Refining Exposition, 44th National AIChE Meeting, Roosevelt Hotel, New Orleans, La. Feb. 26-March 1

MARCH

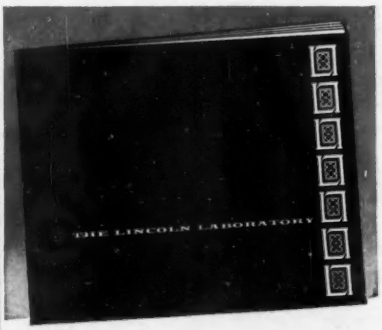
Instrument Society of America, 11th Annual Spring Conference on Instrumentation for the Iron and Steel Industry, Roosevelt Hotel, Pittsburgh, Pa. March 8-9

American Institute of Electrical Engineers, Second Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, Philadelphia, Pa. March 9-10

Institute of Radio Engineers, International Convention, Coliseum and Waldorf Astoria Hotel, New York March 20-23

American Society for Metals, 13th Western Metal Exposition and Congress, Pan Pacific Auditorium, Los Angeles, Calif. March 20-24

Temperature—Its Measurement and Control in Science and Industry (Third National Symposium), sponsored by American Institute of Physics, ISA, National Bureau of Standards, Columbus, Ohio March 27-31



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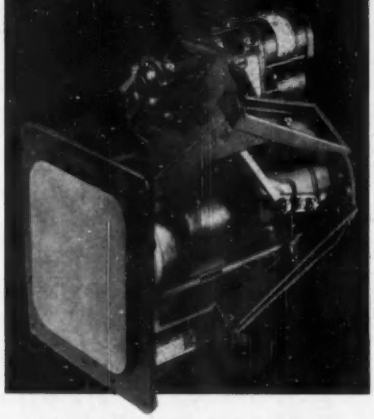

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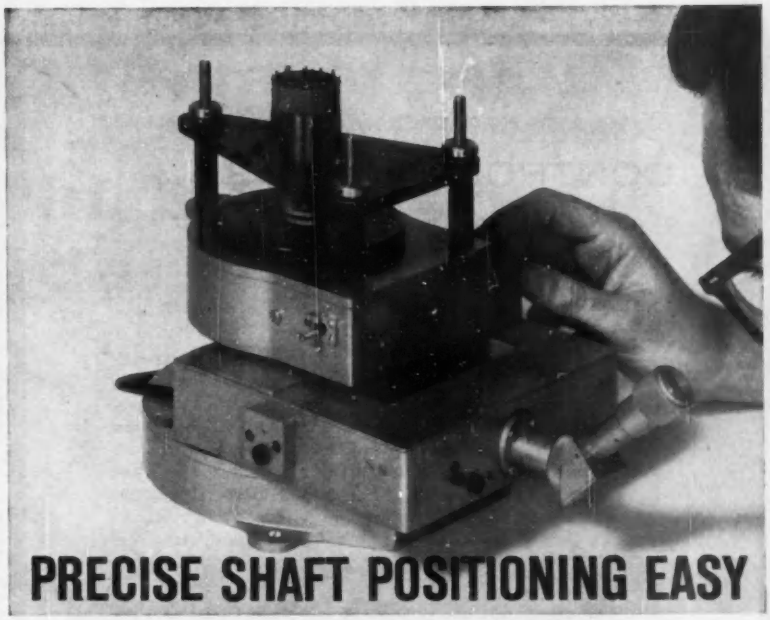

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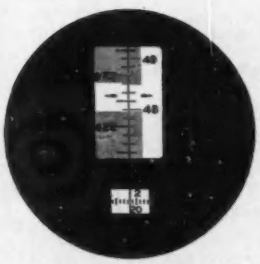

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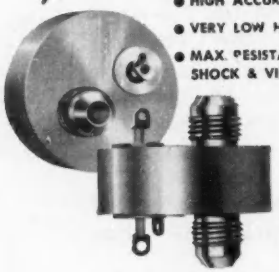

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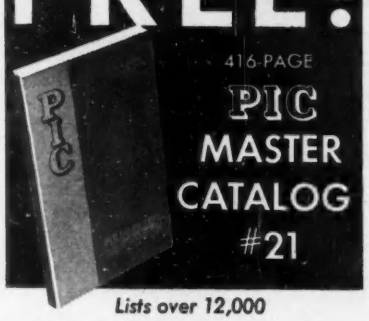

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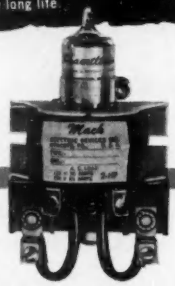

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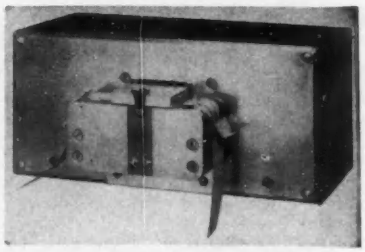

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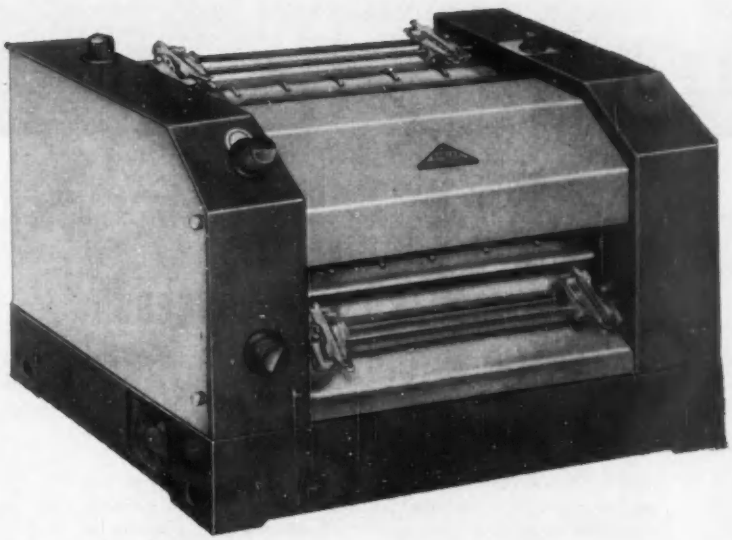

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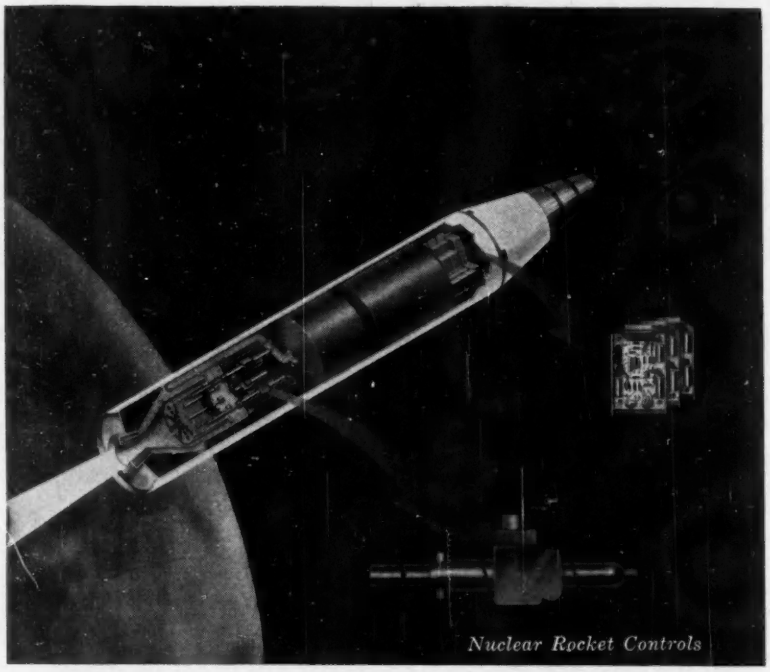
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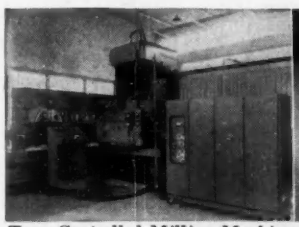
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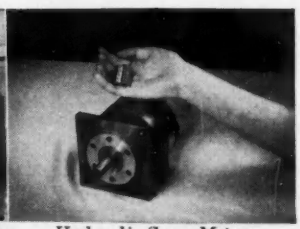
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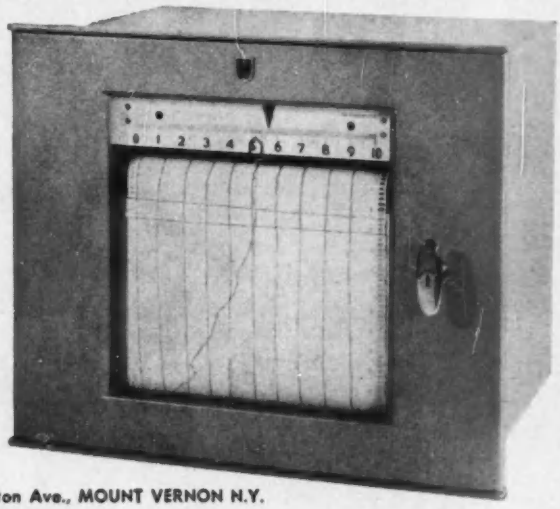

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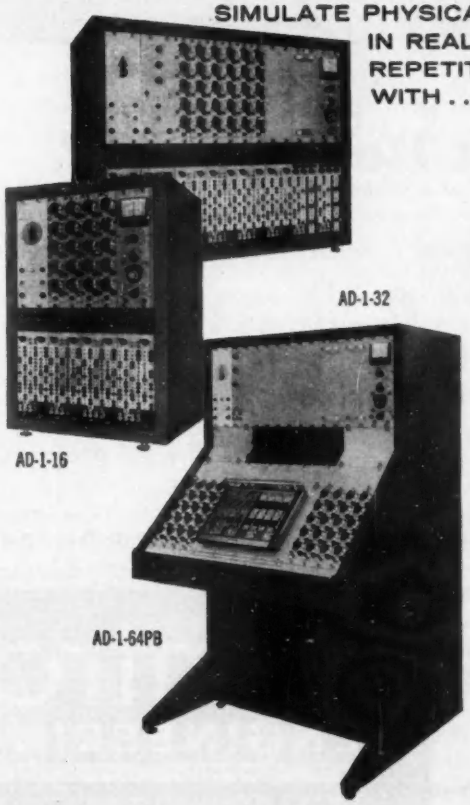

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A Subsidiary of Bowmar Instrument Corp.

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CONTROL ENGINEERING
BOX 12, NEW YORK 36, N.Y.

Employment Opportunities Section
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New York 36, N. Y.

Control
ENGINEERING
INSTRUMENTATION AND CONTROL SYSTEMS
A McGRAW-HILL PUBLICATION

How American Industry Points The Way To Sustained Prosperity in 1961

Something new and very constructive is happening in American industry. It promises to add a major element of strength to business not only in 1961 but right along over the years ahead.

What is happening is essentially this. **American industry is planning to continue to invest heavily in new and better producing facilities in spite of the fact that it has an excess of capacity to produce its present range of products. And, by doing so, business is helping to shape a stronger American economy.** For the continuation of a high level of capital investment by business is one of the most important keys to sustained prosperity.

News of this major new development in American industry is provided by the results of the McGraw-Hill Fall Survey of Business Investment Plans for 1961 and 1962, presented in detail at the right. The McGraw-Hill investment surveys, now in their 13th year, cover a broad cross-section of American industry.

How American industry is aiming to go ahead with a big investment program in spite of its present burden of excess producing capacity is highlighted by the plans of manufacturing companies. The McGraw-Hill fall survey finds that, on the average, these companies are using slightly less than 80 per cent of their producing capacity. They would like to be using well over 90 per cent.

Dramatic New Departure

If historic investment patterns were being followed, our manufacturing companies, with only about 80 per cent of their capacity being employed, would be cutting back new investment programs drastically, and cutting down prosperity in the process. **But — and here is the dramatic new fact — they plan almost no cut-backs in their investment programs.** They plan to invest almost as much (within 3%) in 1961 as they are investing this year. And this year they are investing 19 per cent more than they did in 1959.

There are two major reasons why American industry is unwilling to let its excess producing capacity stall its investment in new facilities until the capacity is more fully used. One is that a lot of this capacity is obsolete and costly to operate. Increasingly rugged competition is creating a strong inducement to replace this antique capacity with modern, more efficient equipment which is widely available.

PLANS FOR CAPITAL SPENDING
(Billions of Dollars)

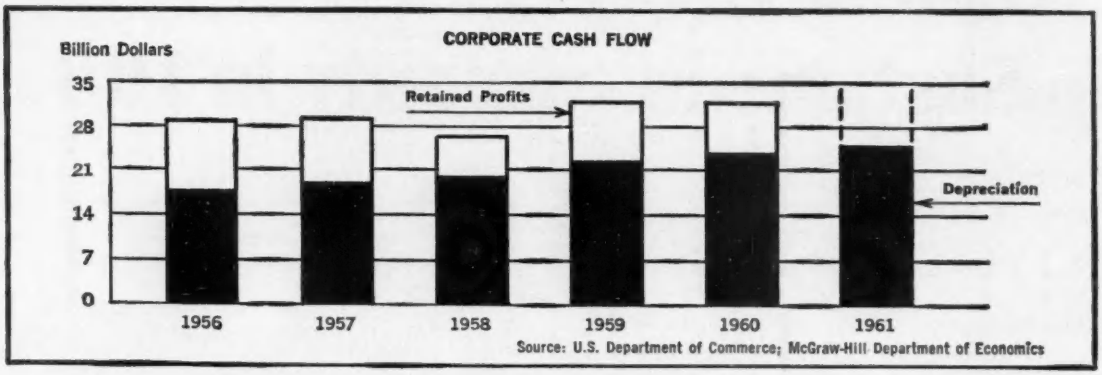
INDUSTRY	1959 Actual*	1960 Estimated*	1961 Planned	1960-1961 % Change	1962 Planned
Iron and Steel	$1.04	$1.52	$1.37	—10%	$1.18
Nonferrous Metals	.31	.34	.34	0	.32
Machinery	.91	1.15	1.11	— 3	1.11
Electrical Machinery	.52	.62	.68	+10	.63
Autos, Trucks & Parts	.64	.89	.95	+ 7	1.02
Transportation Equipment (Aircraft, Ships, R.R. Eq'pt.)	.39	.41	.37	—10	.35
Other Metalworking	.89	.97	.85	—12	.87
Chemicals	1.24	1.61	1.64	+ 2	1.59
Paper and Pulp	.63	.75	.69	— 8	.53
Rubber	.19	.24	.23	— 4	.20
Stone, Clay and Glass	.53	.63	.56	—11	.55
Petroleum & Coal Products	2.49	2.45	2.52	+ 3	2.50
Food and Beverages	.82	.94	.99	+ 5	.97
Textiles	.41	.53	.42	—21	.40
Miscellaneous Manufacturing	1.07	1.28	1.21	— 5	1.13
ALL MANUFACTURING	12.07	14.33	13.93	— 3	13.35
Mining	.99	.99	.90	— 9	.89
Railroads	.92	1.04	.79	—24	.83
Other Transportation & Communications	4.69	5.20	4.61	—11	4.18
Electric And Gas Utilities	5.67	5.89	6.14	+ 4	6.01
Commercial (1)	8.21	8.61	8.70	+ 1	8.54
ALL BUSINESS	32.55	36.06	35.07	— 3	33.80

*U.S. Department of Commerce, Securities and Exchange Commission, McGraw-Hill Department of Economics.

(1) Figure based on large chain, mail order and department stores, insurance companies, banks and other commercial businesses.

"R And D" Paves The Way

The steel industry provides a good case in point. Despite an operating rate of little more than 50 per cent during the last six months, steel companies plan a total investment of nearly $1.4 billion in 1961. And though this is 10 per cent below their capital expenditures in 1960, it will still be the third highest year on record.



Also, new investment is required to tool up for the manufacture of the new products being spawned by the continuing boom in industrial research and development. This year, we are spending about $13 billion (that's *billion*) for all research and development, about $9.6 billion of it through industry.* And out of it is coming the "know-how" for a veritable flood of new products, processes and equipment, most all of these calling for new producing equipment. Next year, American manufacturers plan to get 12 per cent of their sales in products that did not even exist four years ago.

Key Role Of Depreciation Reserves

A major reason why American industry can combine the desire to carry out big new investment programs with the necessary financial capacity to do it is to be found in the growth of its reserves for depreciation. This year, (1960), business has been in a squeeze between costs and the prices it could get for its products. This cost-price squeeze has reduced profits sharply. The total of profits for the year will be down about 5 per cent.

Allowances for the depreciation of existing plant and equipment, however, have continued to rise. The result is that the so-called cash flow of corporations (their retained profits plus their allowances for depreciation) is the same this year as last. And this cash flow, shown in the chart above, makes a decisive contribution to financing new investment.

Inflation Would Be Deadly

If the sort of profit squeeze that has prevailed this year were to become chronic, it would blight both the incentive and wherewithal to continue a vigorous program of new investment. In addition, if price inflation were to begin surging again, it would eat away the power of depreciation reserves to purchase new plant and equipment.

The allowances now permitted American industrial firms for the depreciation of their producing facilities are lower than those made in any of the industrial countries with which we are in increasingly tough competition. More adequate allowances would speed up the job of modernizing American industry. An earlier McGraw-Hill survey indicated that it would cost only slightly less than $100 billion to bring our nation's plant and equipment up to date.

But at this juncture, American industry's eagerness and capacity to maintain a high level of investment capital is adding a great new element of constructive strength to the nation's economy.

---

*The significance of this boom for American industry is analyzed in a new McGraw-Hill book, "The Research Revolution" by Leonard Silk, Economics Editor of BUSINESS WEEK. Together with other new business investment trends the "R & D" boom also constitutes a key part of another new McGraw-Hill book, "New Forces in American Business" by Dexter M. Keezer and associates — the November selection of the Business Book Club.

This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

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Sigma	52JOCA-80110	1A1C	16,000 Ohm	28VDC	3.00
Sigma	7-JOZ-80030 None Pile Up Cont.	SPDT	5000 Ohm	28VDC	2.50
		3A3B	144 Ohm	12VDC	1.00
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Clare	B65389	1A1B	125 Ohm	12VDC	1.50
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Check the advertisements in the SEARCHLIGHT section. If what you seek is not currently advertised, fill out the form below or use your company letterhead, giving complete specifications and mail to:

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Classified Advertising Division
CONTROL ENGINEERING
P. O. Box 12, New York 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in SEARCHLIGHT. You will receive replies directly from them.

SEARCHLIGHT Equipment Locating Service
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STATE I/61

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rms/piv	rms/piv	rms/piv	rms/piv
280/400 55¢	350/500 70¢	420/600 $1.00	490/700 $1.25
rms/piv	rms/piv	rms/piv	rms/piv
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Division of Schlumberger

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Resistance: 140 ohms ±5%
Dielectric Strength: 500 VDC
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Response Time: Better than 5 ms.
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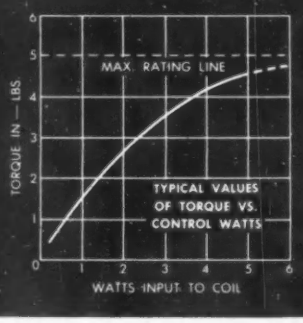

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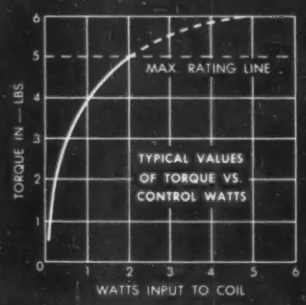

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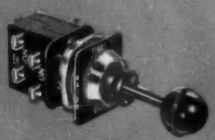

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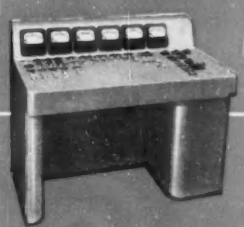

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